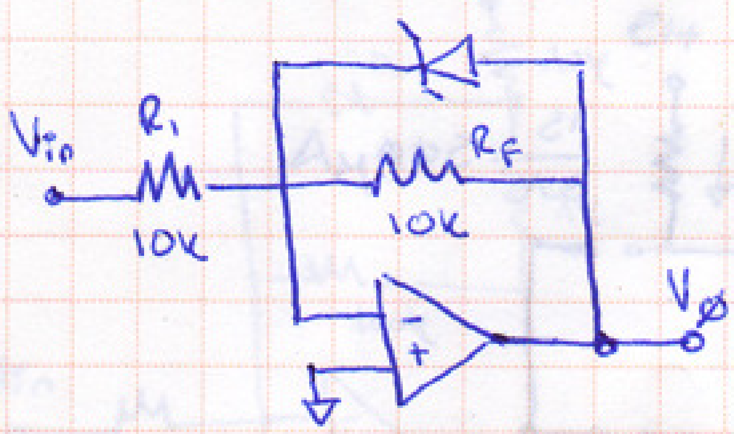
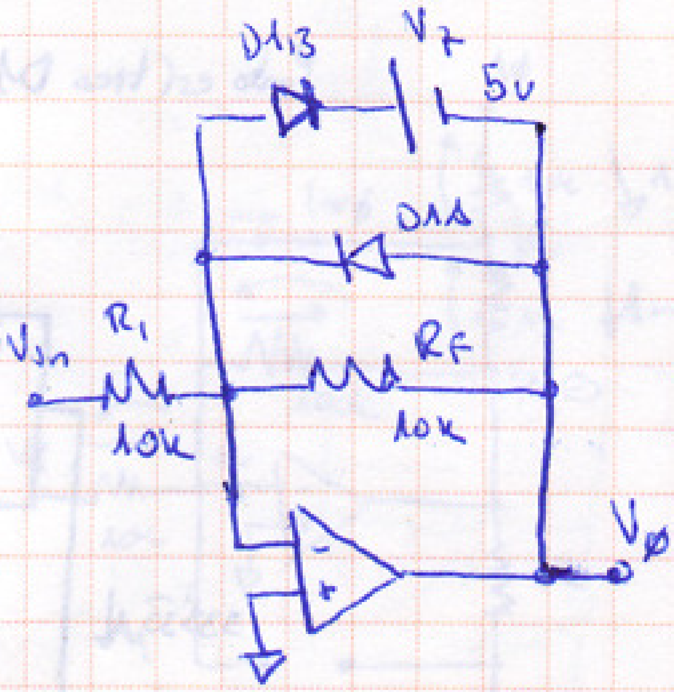
EA - Punto crítico ✓



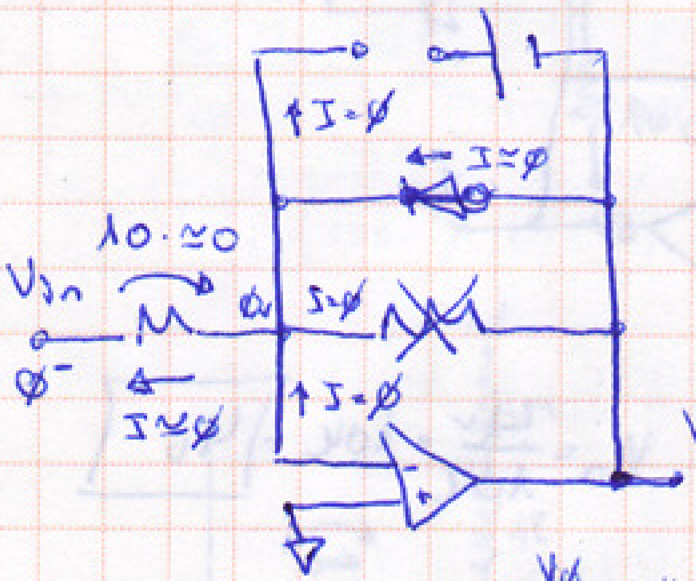


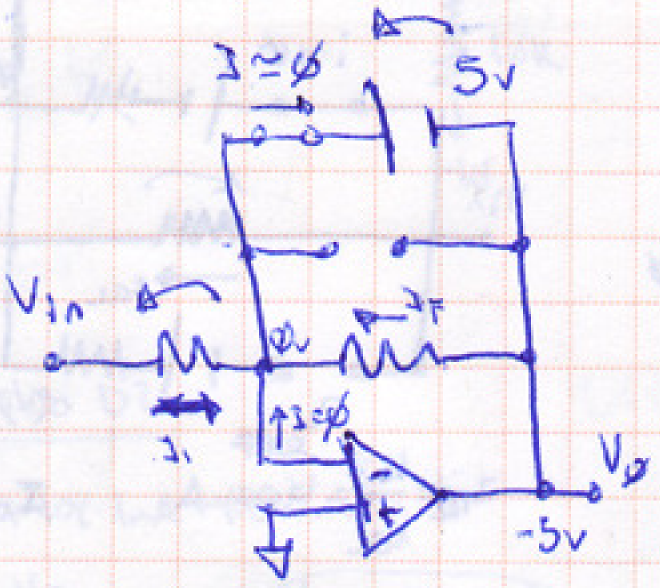
Punto crítico D1A:

$V_{in} = \emptyset^-$ D1B = OFF

Punto crítico D1B:

$V_{in} = 5v$ D1A = OFF

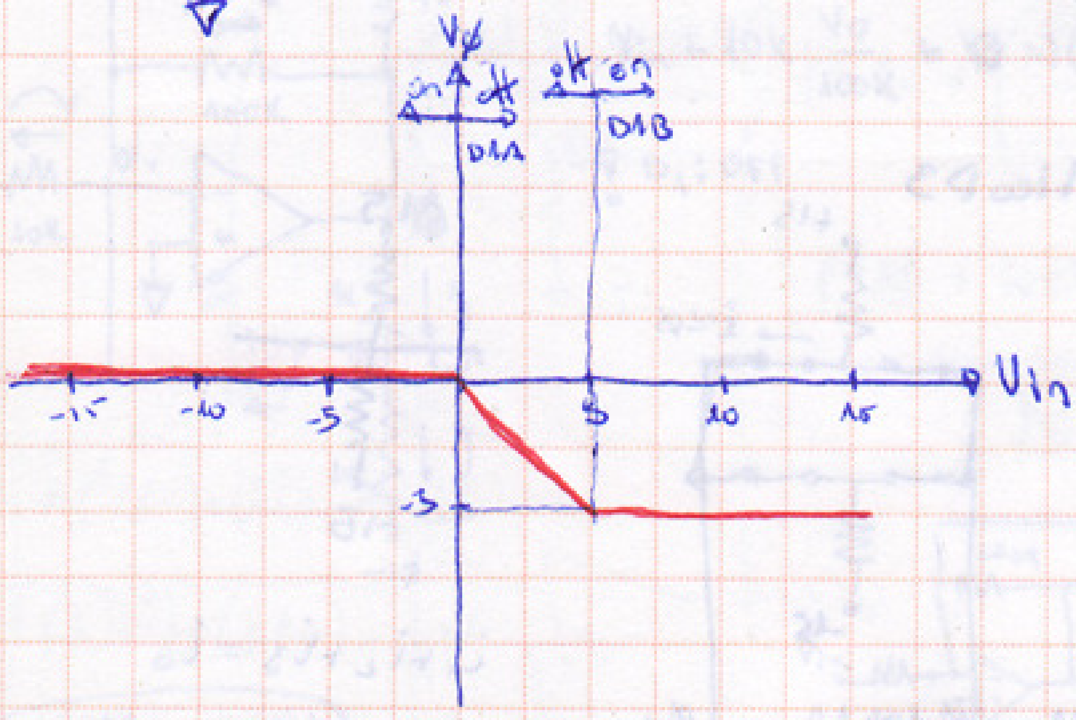


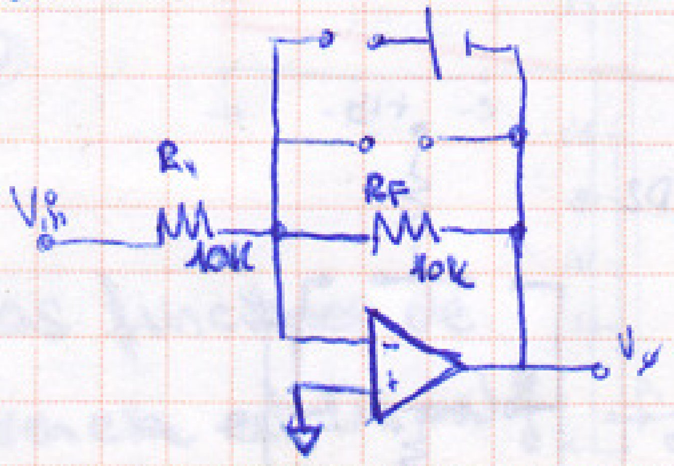


$I_F = \frac{5v}{10k} = 0'5mA$

$I_1 = I_F$

$V_{in} = I_F \cdot 10k = 5v$





Inversor

$V_\emptyset = -V_{in}\left(\frac{R_F}{R_1}\right)$

$V_\emptyset = -V_{in}$

II - Sumas y restas

ACC	ACC.7	OV	C
8Eh	1	∅	∅

→ OK!

CLR C
MOV A,#∅A3H → 10100011 (+93)
SUBB A,#15H → 00010101 (21)
∅ 10001110 (-114)
01110010

MOV A,#65H → 01100101 (101)
ADD A,#∅A3H → + 10100011 (163)
1 00001000

+ 01100101 (101)
10100011 (-93)
1 00001000

01011100

ACC	ACC.7	OV	C
∅8h	∅	∅	1

→ INCORRECTO! Con 8 bits sólo podemos representar hasta 255

Sin signo

ACC	ACC.7	OV	C
∅8h	∅	∅	1

→ OK!

Complemento a 2

CLR C
MOV A,#65H → 01100101 (101)
SUBB A,#∅A3H → 10100011 (163)
1 11000010

− 01100101 (101)
10100011 (-93)
1 11000010

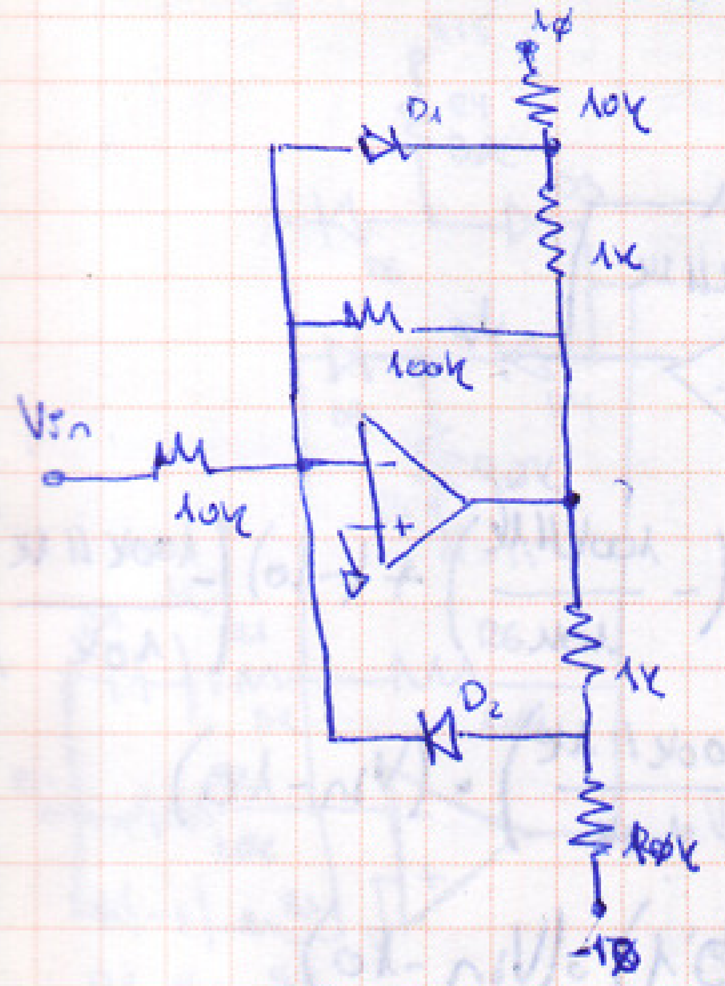
ACC	ACC.7	OV	C
C2h	1	1	1

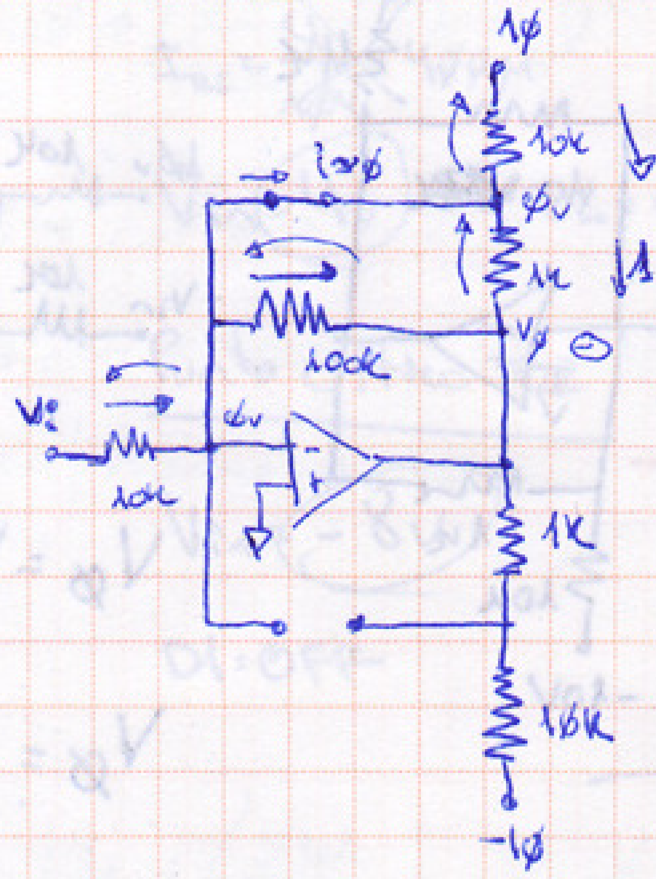
→ INCORRECTO! En codificación sin signo, no podemos representar números negativos

ACC	ACC.7	OV	C
C2h	1	1	1

→ INCORRECTO! Con 7 bits sólo podemos representar hasta 127

EA - Punto crítico ✓





Punto crítico D1

$V_0 = 10 - 10k \cdot 1mA - 1k \cdot 1mA = -1$

$V_{in} - \frac{V_0}{100k} \cdot 10k = 0$ $\quad V_{in} = +100mV$

! D_2: OFF

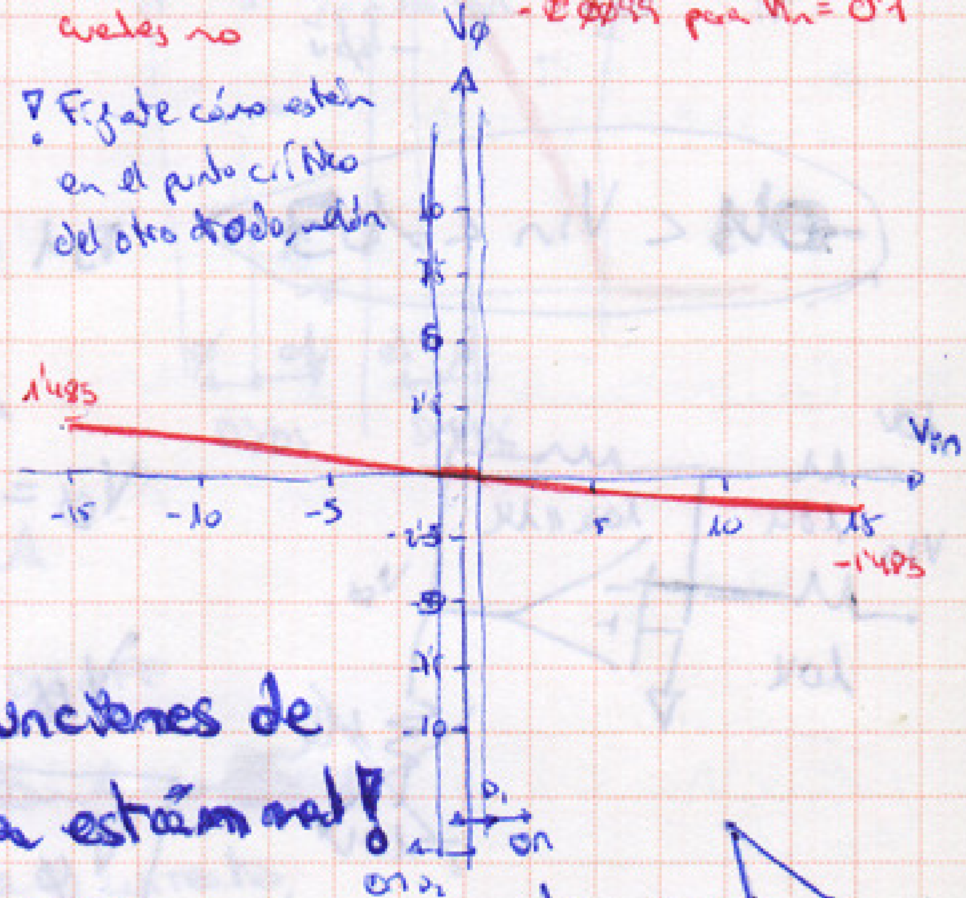
! Una vez calculados los punto críticos, no sé determinar en qué partes están conduciendo y en cuales no

! No se coinciden los puntos críticos con los valores de las ecuaciones de las rectas

-0'0099 para $V_{in} = -0'1$

-0'0099 para $V_{in} = 0'1$

! Fíjate cómo están en el punto crítico del otro diodo, nada

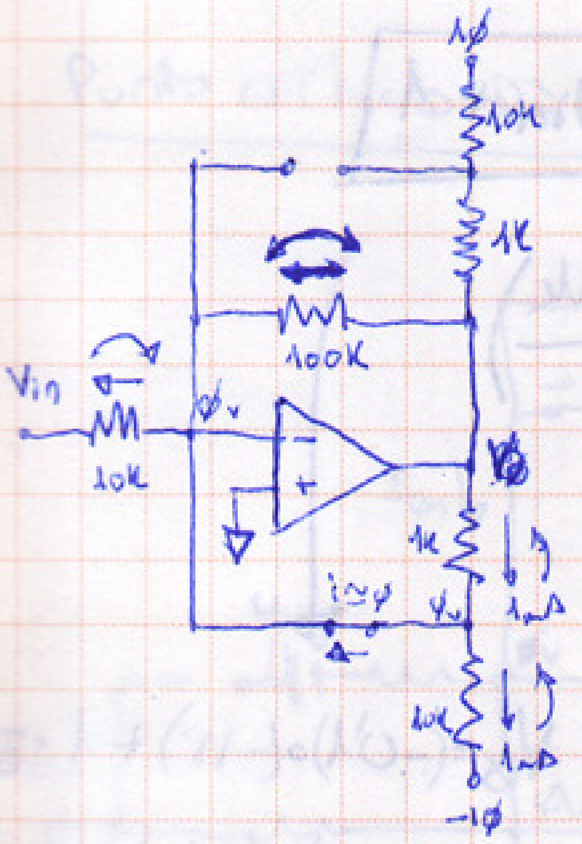


Punto crítico D2

$V_0 = -10 + 10k \cdot 1mA + 1k \cdot 1mA = 1$

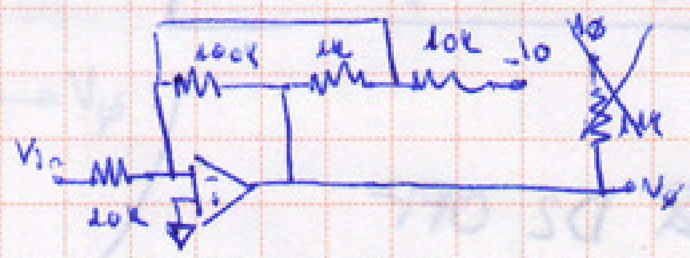
$V_{in} + 10k \cdot \frac{V_0}{100k} = 0 \Rightarrow V_{in} = -100mV$

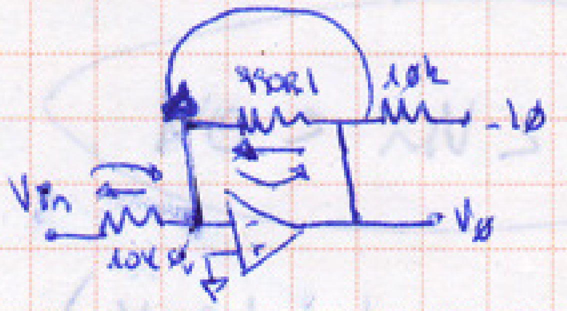
! D_1: OFF



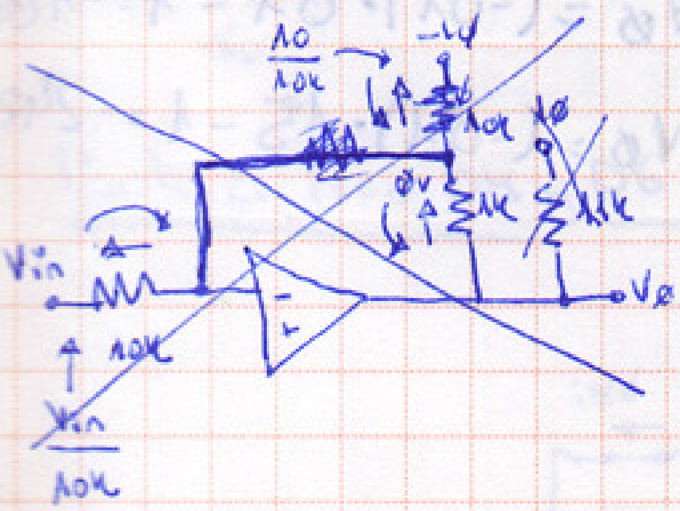
Las funciones de transferencia están mal!

↳ Página siguiente





$-15 < V_{in} < -0'1$ $\quad D_2$ ON



$V_0 = V_{in} + \frac{V_{in}}{10k} + 1k\left(\frac{10}{10k} + \frac{V_{in}}{10k}\right)$

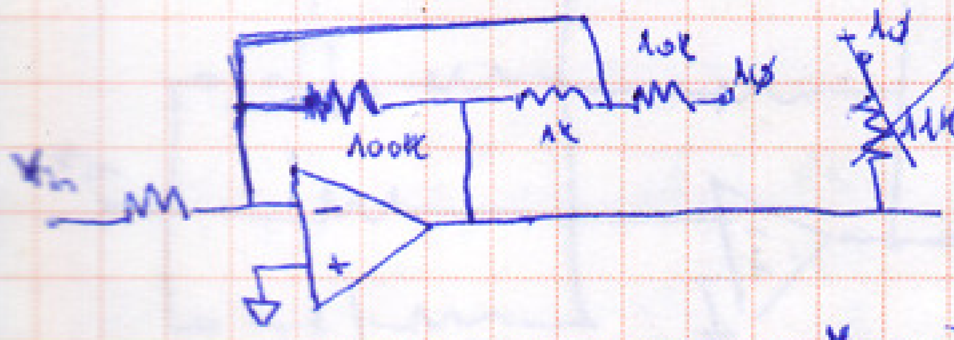
$V_0 = V_{in}\left(1 + \frac{1}{10k}\right) + \frac{10k}{10k} + \frac{1k \cdot V_{in}}{10k} = V_{in}\left(1 + \frac{1}{10k}\right) - 1 + \frac{V_{in}}{10} = V_{in}\left(1 + \frac{10}{10k} + \frac{1}{10}\right) + 1$

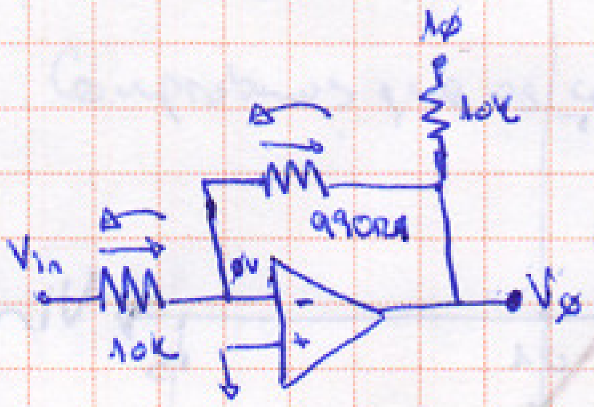
$V_0 = V_{in}\left(\frac{10k + 10 + 1k}{10k}\right) + 1 = V_{in}\frac{11k01}{10k} = \boxed{1'101 \cdot V_{in}}$

$V_0 = -990\Omega \cdot \frac{V_{in}}{10k} = \boxed{-0'1 V_{in}}$ $\qquad -15 = -0'1 V_{in} \Rightarrow V_{in} = 150$

No hay saturación

$0'1 < V_{in} < 15$ $\quad D_1$ ON





$V_0 = V_{in} - \frac{V_{in}}{10k} - 990\Omega \frac{V_{in}}{10k}$

$V_0 = V_{in}\left(1 - \frac{1}{10k} - \frac{990\Omega}{10k}\right)$

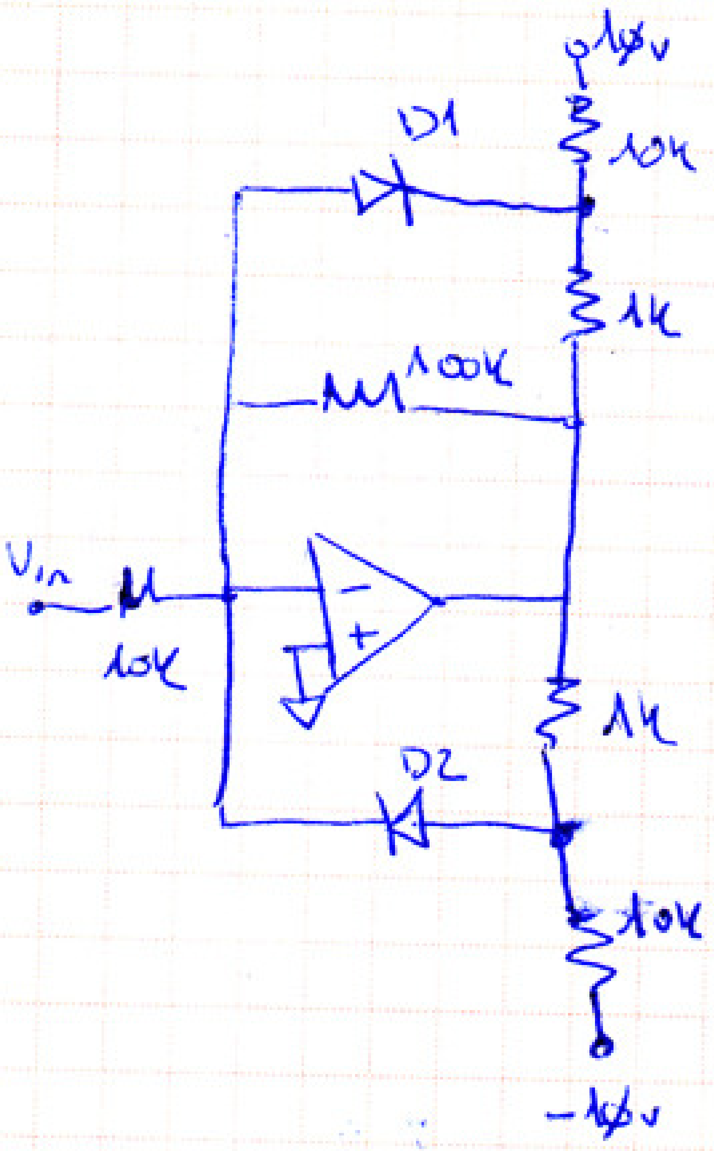
$V_0 = V_{in}\left(1 - \frac{1 + 990\Omega}{10k}\right)$

$V_0 = \boxed{V_{in} \cdot 0'9}$

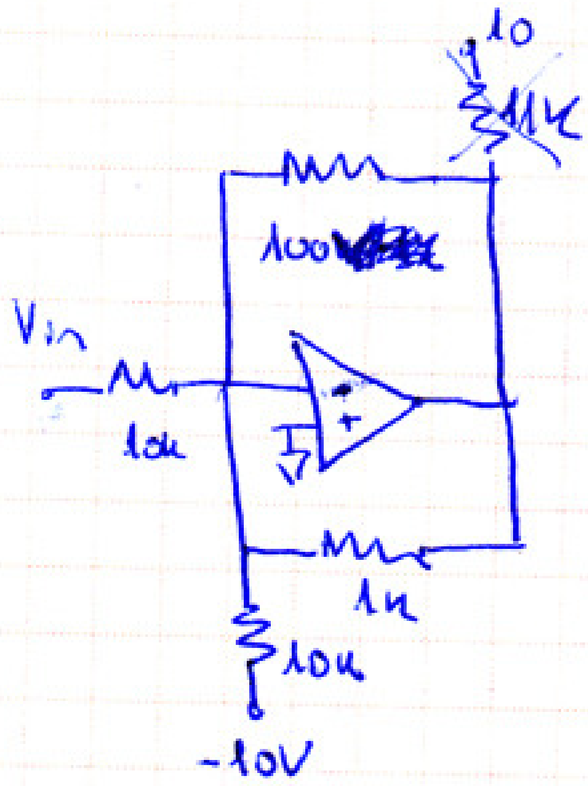
$V_0 = -990\Omega \cdot \frac{V_{in}}{10k} = \boxed{-0'1 V_{in}}$

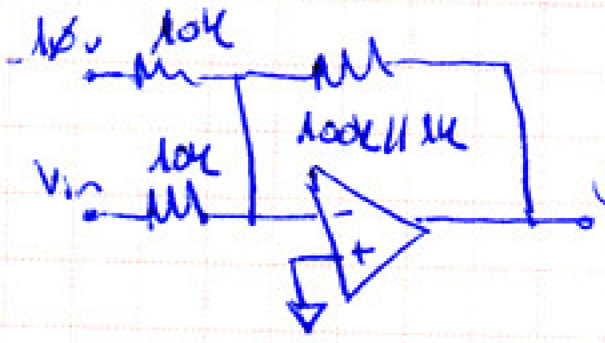
$15 = -0'1 V_{in} \Rightarrow V_{in} = -150$ No hay saturación

$\frac{1}{R_0} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow \frac{1}{R_0} = \frac{R_2}{R_1 R_2} + \frac{R_1}{R_1 R_2} = \frac{R_2 + R_1}{R_1 R_2} \Rightarrow R_0 = \frac{R_1 R_2}{R_1 + R_2}$



-15 < Vin < -0'1 D2 ON





$$V_\varnothing = V_{in}\left(-\frac{100k \parallel 1k}{10k}\right) + (-10)\left(-\frac{100k \parallel 1k}{10k}\right)$$

$$V_\varnothing = \left(-\frac{100k \parallel 1k}{10k}\right)\cdot(V_{in}-10)$$

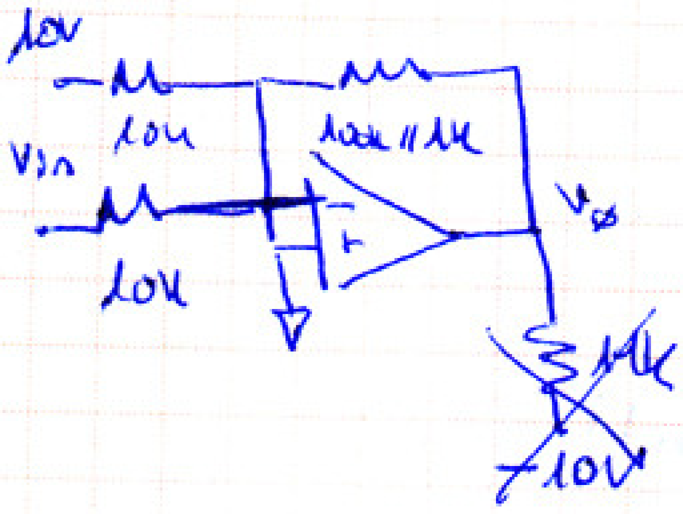
$$V_\varnothing = (-0'1)\cdot(V_{in}-10)$$

$$\boxed{V_\varnothing = -0'1V_{in}+1}$$

$$V_\varnothing = (-0'1)\cdot(-15)+1 = 2'485$$

$$V_\varnothing = (-0'1)\cdot(-0'1)+1 = 1'009$$

0'1 < Vin < 15 D1 ON



$$V_\varnothing = V_{in}\left(-\frac{100k \parallel 1k}{10k}\right) + (10)\left(-\frac{100k \parallel 1k}{10k}\right)$$

$$V_\varnothing = (-0'1)\cdot(V_{in}+10)$$

$$\boxed{V_\varnothing = -0'1V_{in} - 1}$$

$$V_\varnothing = (-0'1)\cdot 0'1 - 1 = -1'009$$

$$V_\varnothing = (-0'1)\cdot 15 - 1 = -2'485$$

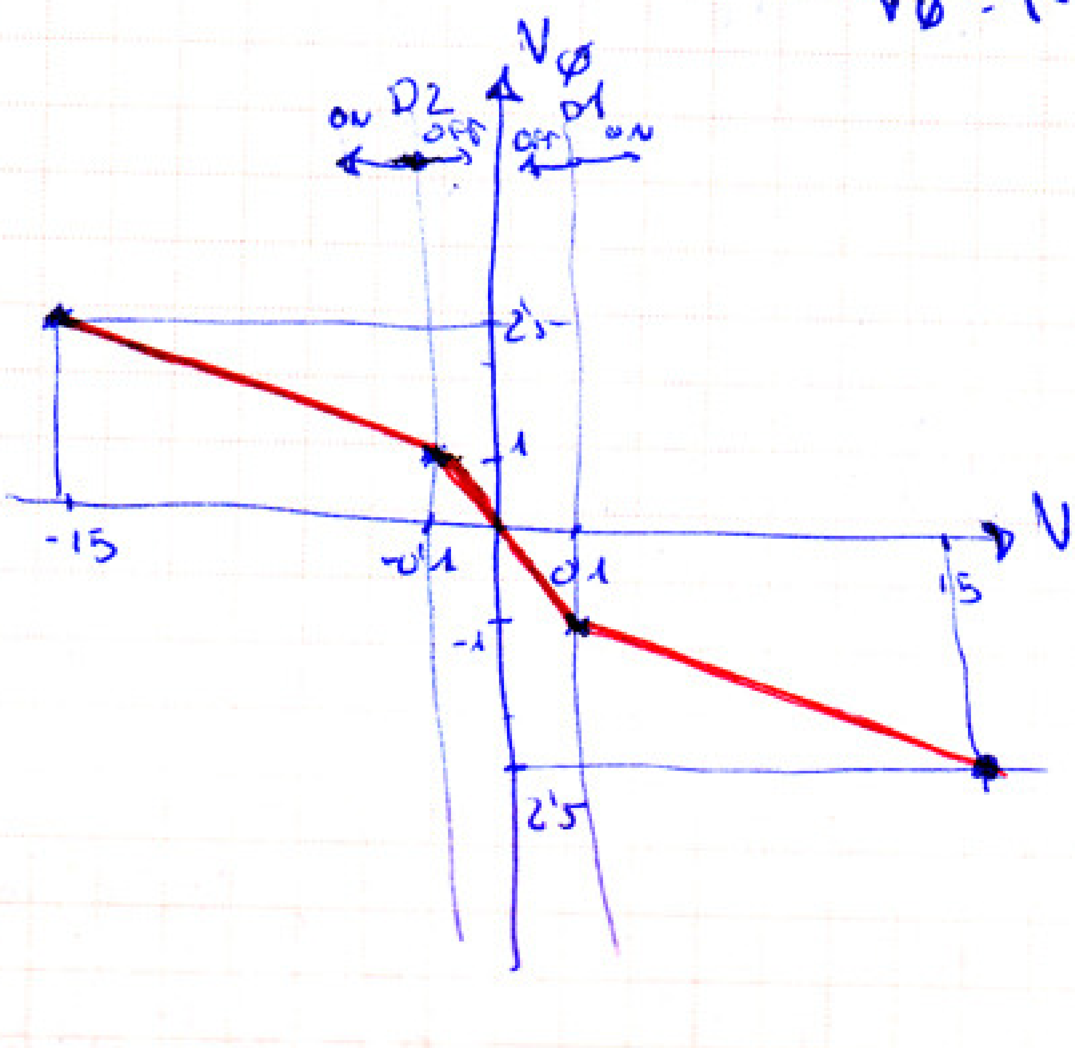
-0'1 < Vin < 0'1 D1 & D2 OFF

$$V_\varnothing = V_{in}\left(-\frac{100k}{10k}\right) = -10V_{in}$$

$$\boxed{V_\varnothing = -10V_{in}}$$

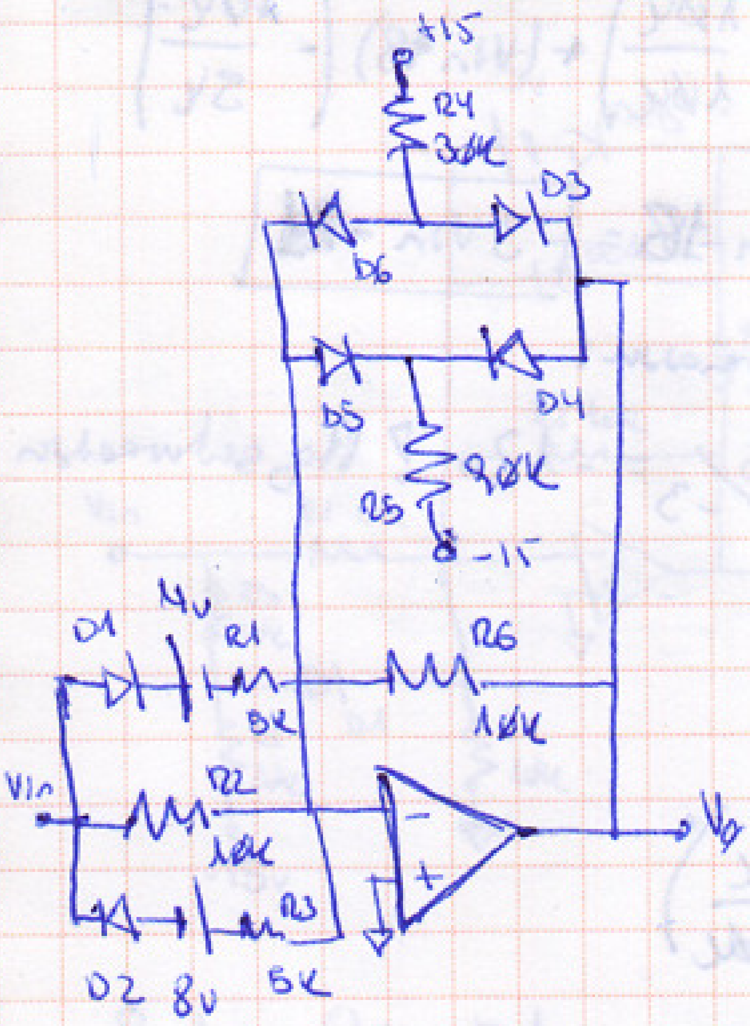
$$V_\varnothing = (-10)\cdot(-0'1) = 1$$

$$V_\varnothing = (-10)\cdot(0'1) = -1$$



E1 - Punto crítico

*Resuelto ✓



Punto crítico D1

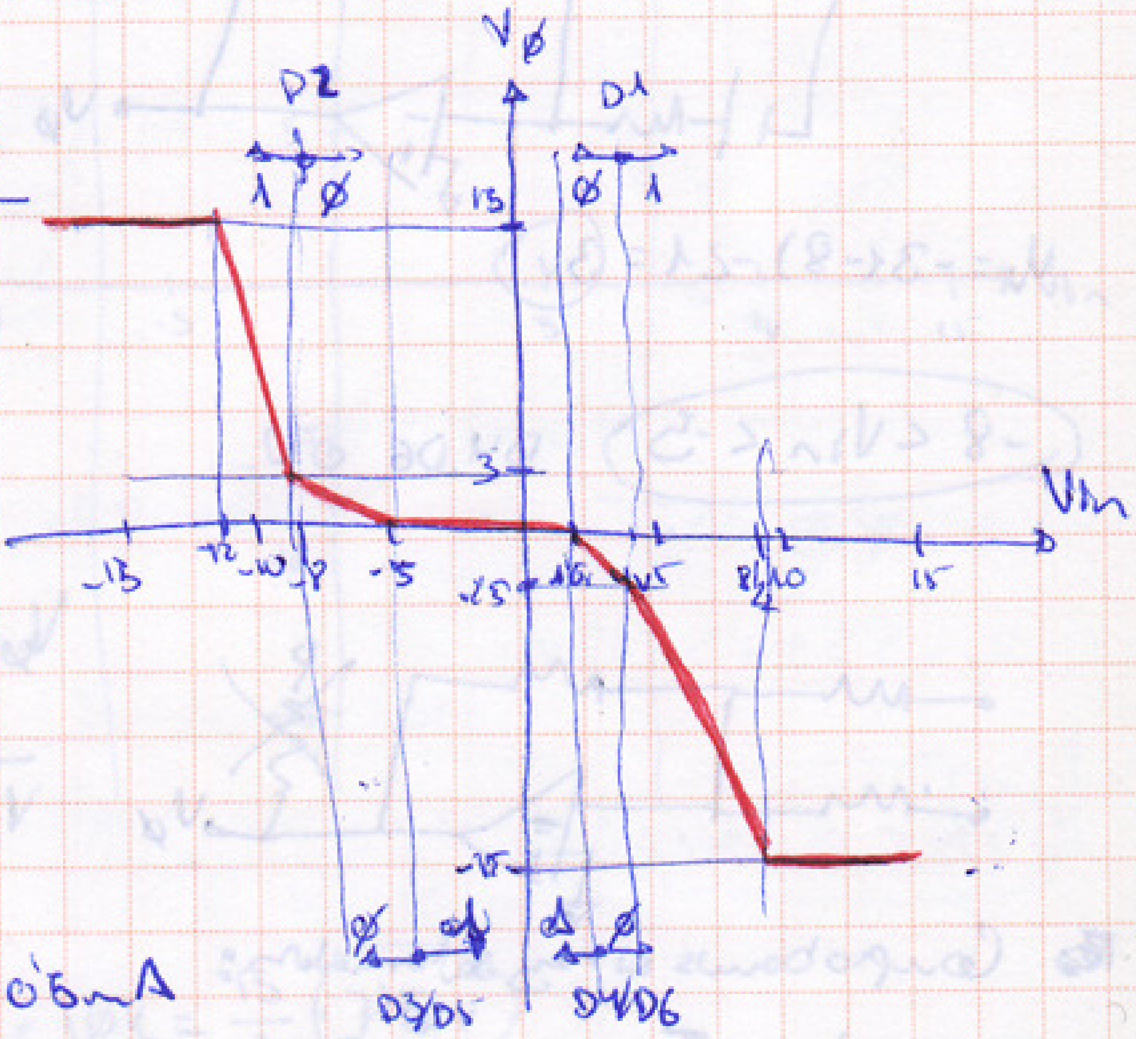
$I_{R1} = \frac{4}{10k} = 400\mu$

$V_{in} = 4v$ D2 = OFF

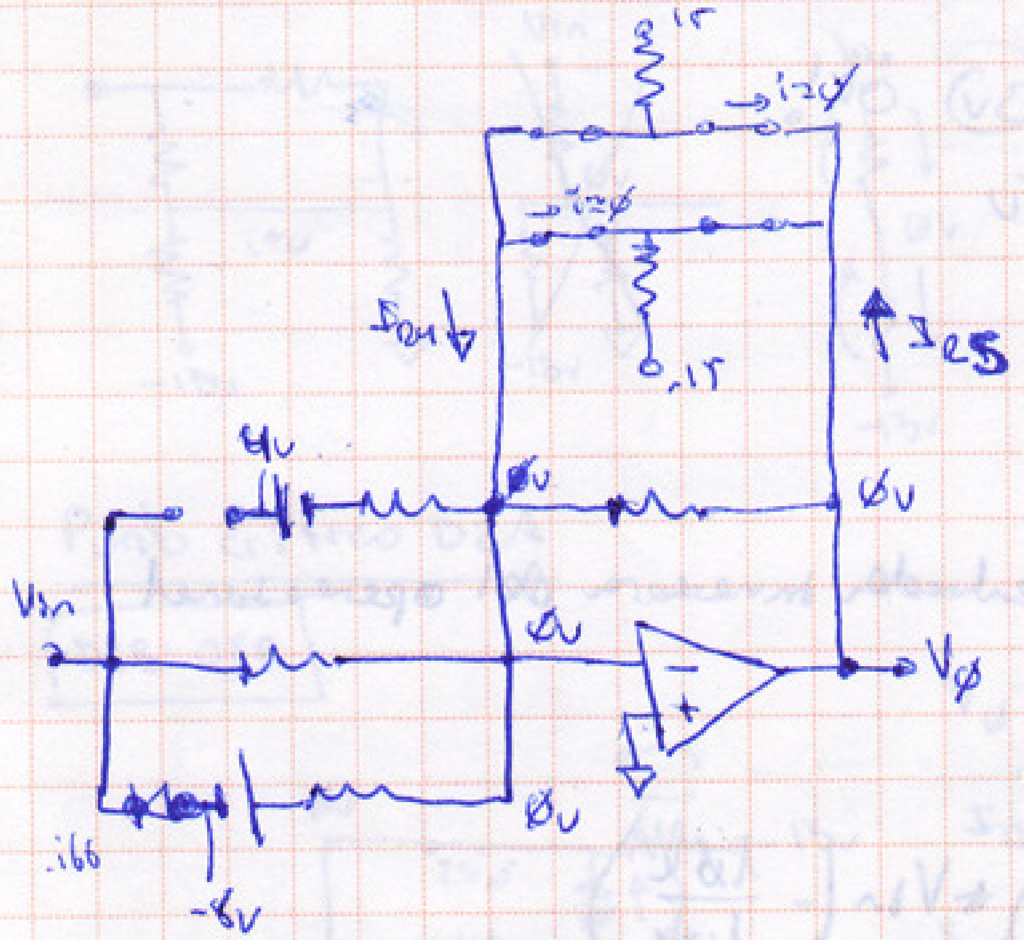
Punto crítico D2

$V_{in} = -8v$

D1: OFF



Punto crítico D3 y D5



$I_{R4} = \frac{15}{30k} = 0'5mA$

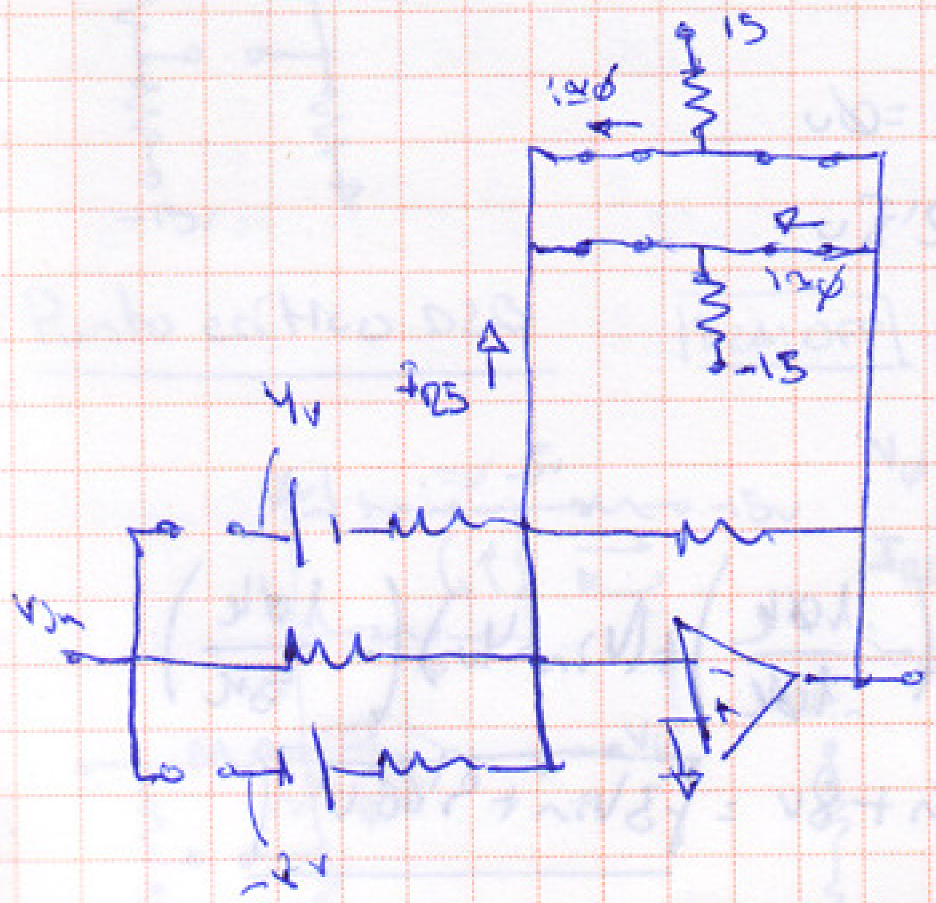
$I_{R5} = \frac{15}{90k} = 0'16mA$

Suponemos D1 OFF y D2 OFF

$V_{in} = 0 - 10k \cdot 0'5mA = -5V$

Comprobamos que es correcto.

Punto crítico D4 y D6



$I_{R4} = 0'5mA$

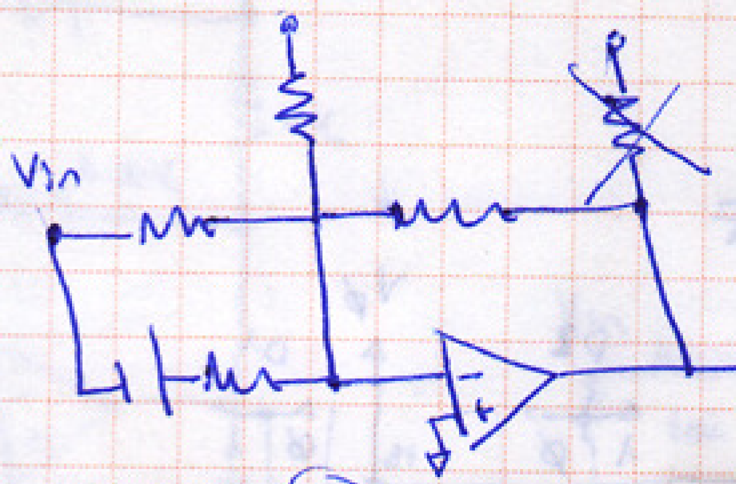
$I_{R5} = 0'16mA$

Suponemos D1 OFF y D2 OFF

$V_{in} = 10k \cdot 0'16mA = 1'6V$.

Comprobamos que es correcto

$-15 < V_{in} < -8$ D2, D4, D6 ON



$V_\emptyset = 15\left(-\frac{10k}{30k}\right) + V_{in}\left(-\frac{10k}{10k}\right) + (V_{in}+8)\left(-\frac{10k}{5k}\right)$

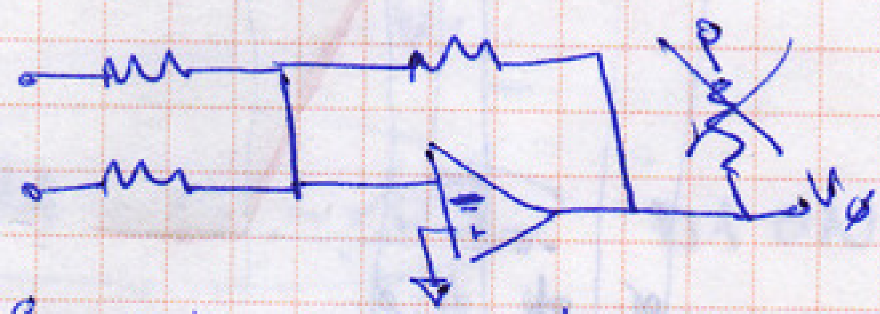
$V_\emptyset = -5 - V_{in} - 2V_{in} - 16 = \boxed{-3V_{in} - 21}$

Comprobamos si hay saturación:

$15 = -3V_{in} - 21 \Rightarrow 36/_{-3} = -12v$ ¡Hay saturación!

$V_\emptyset = -3(-8) - 21 = 3v$

$-8 < V_{in} < -5$ D4, D6 ON



$V_\emptyset = V_{in}\left(-\frac{10k}{10k}\right) + 15\left(-\frac{10k}{30k}\right)$

$V_\emptyset = \boxed{-V_{in} - 5}$

Comprobamos si hay saturación:

$15 = -V_{in} - 5$ $V_{in} = -20$

No hay

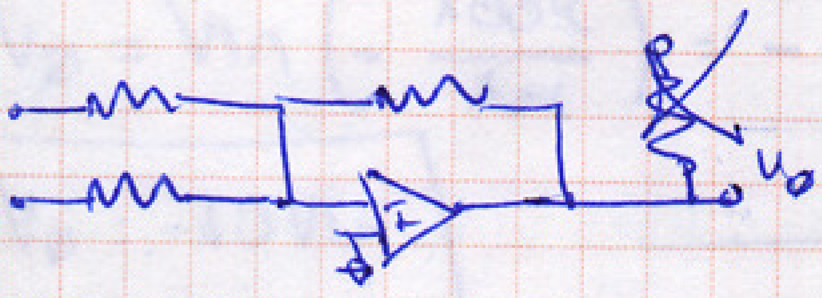
$V_\emptyset = +8 - 5 = 3v$ ok!

$V_\emptyset = 5 - 5 = 0v$

$-5 < V_{in} < 1'66$ D3, D5, D4, D6 ON

$V_\emptyset = \emptyset$ por estar cortocircuitadas la salida y la entrada inversora del operacional

$1'66 < V_{in} < 4$ D3, D5, ON



$V_\emptyset = -15\left(-\frac{10k}{90k}\right) + V_{in}\left(-\frac{10k}{10k}\right)$

$V_\emptyset = \boxed{-V_{in} + 1'66\,V}$

Comprobamos si hay saturación:

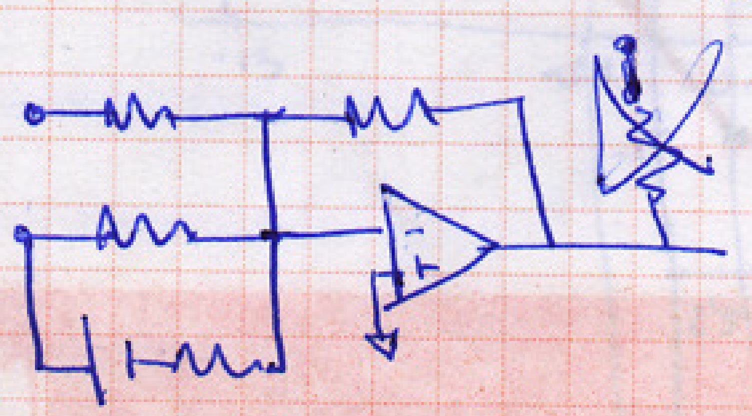
$-15 = -V_{in} + 1'66v$ $V_{in} = 16'66v$

No hay

$V_\emptyset = -1'66 + 1'66 = 0v$

$V_\emptyset = -4 + 1'66 = -2'3v$

$4 < V_{in} < 15$ D3, D5, D1 ON



$V_\emptyset = -15\left(-\frac{10k}{90k}\right) + V_{in}\left(-\frac{10k}{10k}\right) + (V_{in} - 4)\left(-\frac{10k}{5k}\right)$

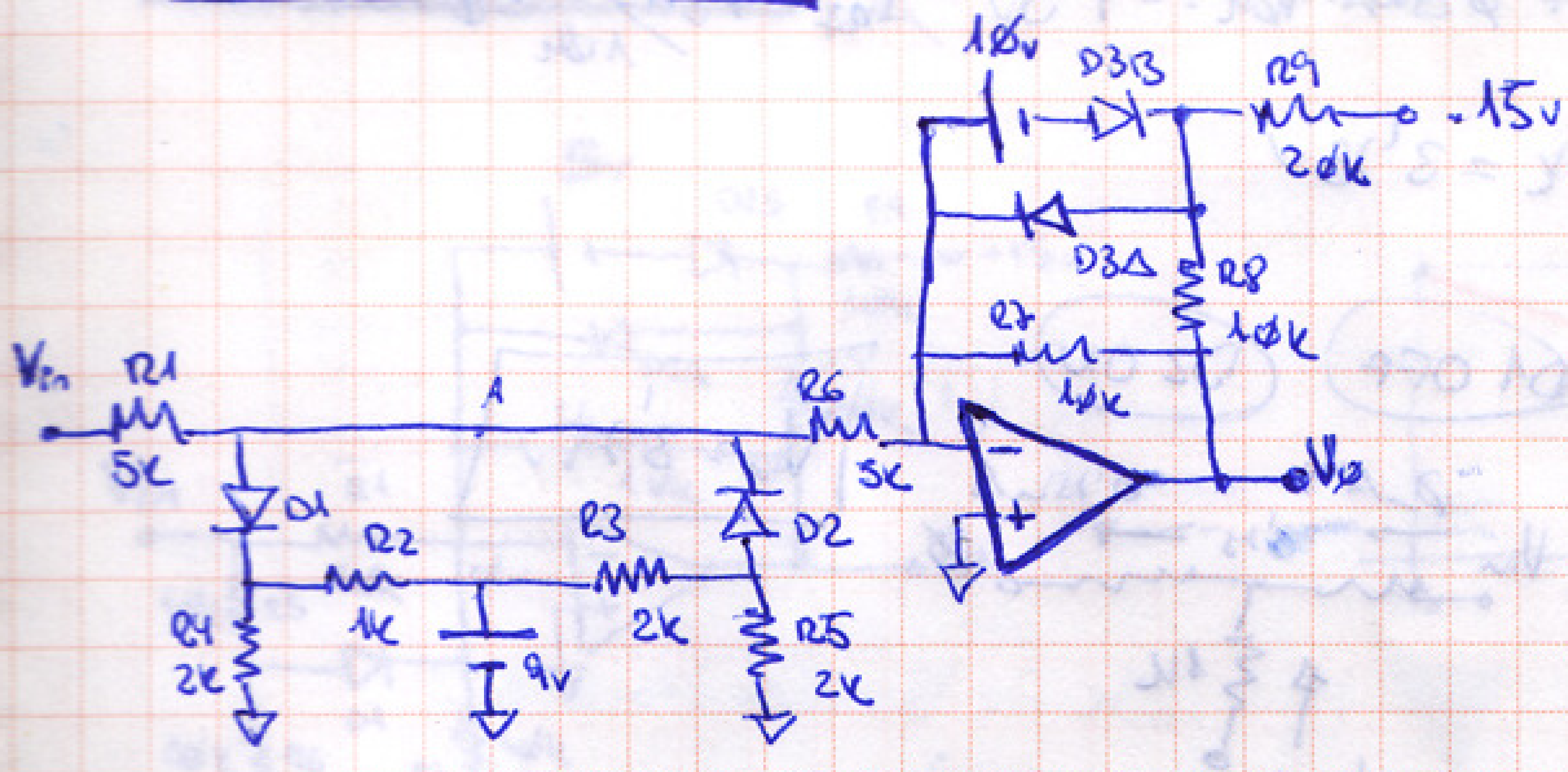
$V_\emptyset = 1'66V - V_{in} - 2V_{in} + 8v = \boxed{-3V_{in} + 9'66V}$

Comprobamos si hay saturación:

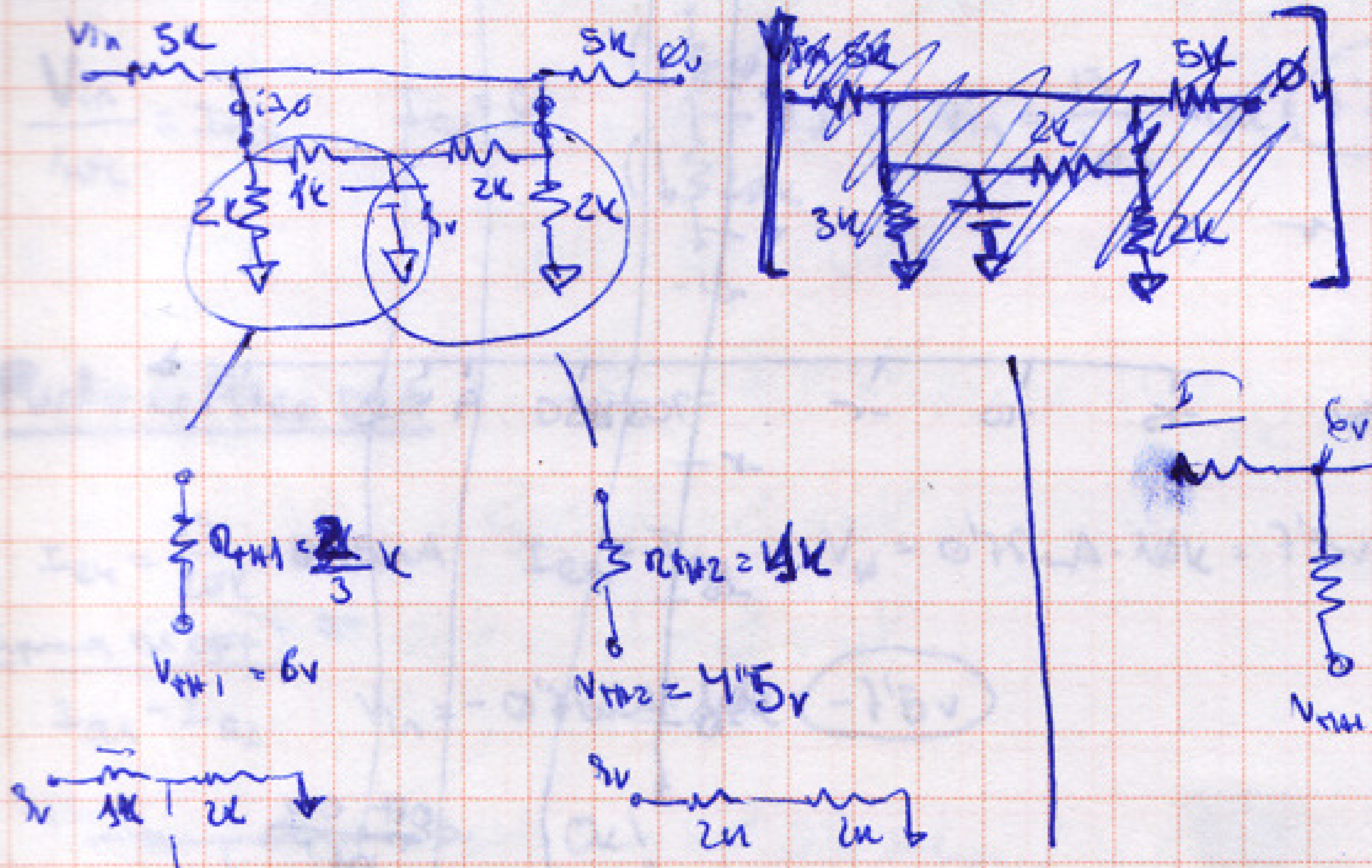
$-15 = -3V_{in} + 9'66v \rightarrow V_{in} = 8'22v$ ¡Hay saturación!

$V_\emptyset = -12\,V_{in} + 9'66 = 2'33v$

EA - Punto crítico



Punto crítico D1

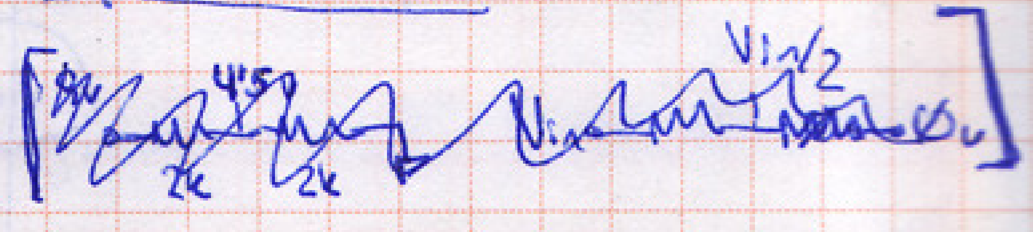


$R_{TH1} = \frac{2}{3}k$ $R_{TH2} = 1k$

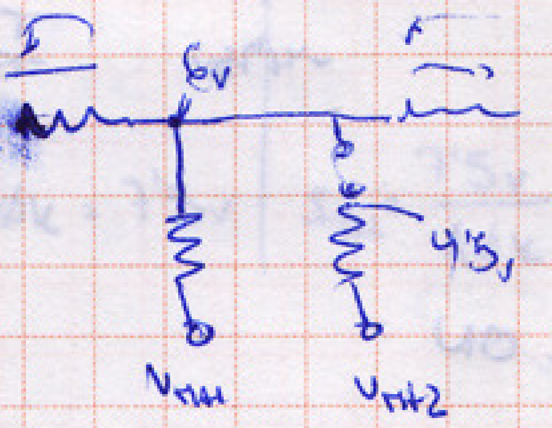
$V_{TH1} = 6v$ $V_{TH2} = 4'5v$

$V_{TH} = \frac{9}{3k} \cdot 2k = 6v$

Suponemos D2: OFF



$V_{in} = 6v + \frac{6}{5k} \cdot 5k = \boxed{12v}$

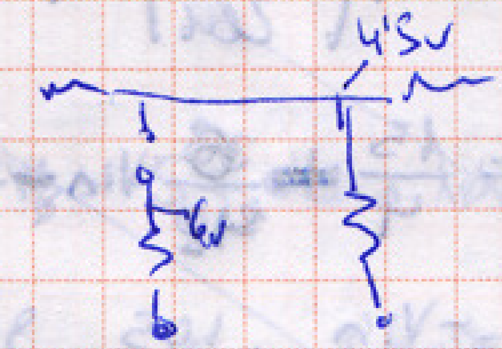


D2: OFF

Punto crítico D2

$V_{in} = 4'5 + \frac{4'5}{5k} 5k = 9v$

Suponemos D1: OFF



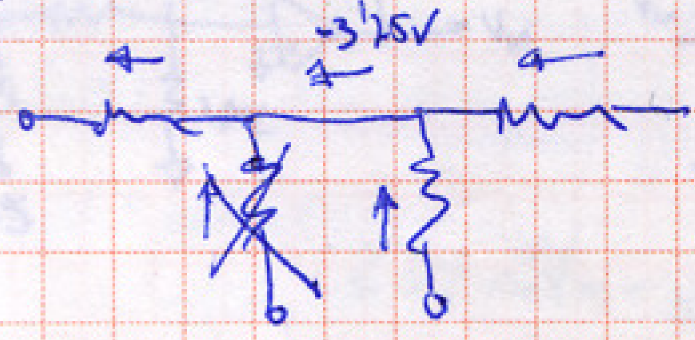
D1: OFF

Punto crítico D3A   D3B: OFF

$I_{R9} = \frac{15}{20k} = 0'75mA$ $I_{R8} = I_{R9}$ $V_o = 0'75mA \cdot 10k = 7'5v$

$I_{R7} = \frac{7'5v}{10k} = 0'75mA$ $I_{R6} = I_{R7}$ $V_A = 0 - 0'75mA \cdot 5k = -3'75v$

D1, D2: ON



$\cancel{\left(0'75mA + \frac{8'25mA}{1k} + \frac{2'25}{2/3k}\right) \cdot 5k}$

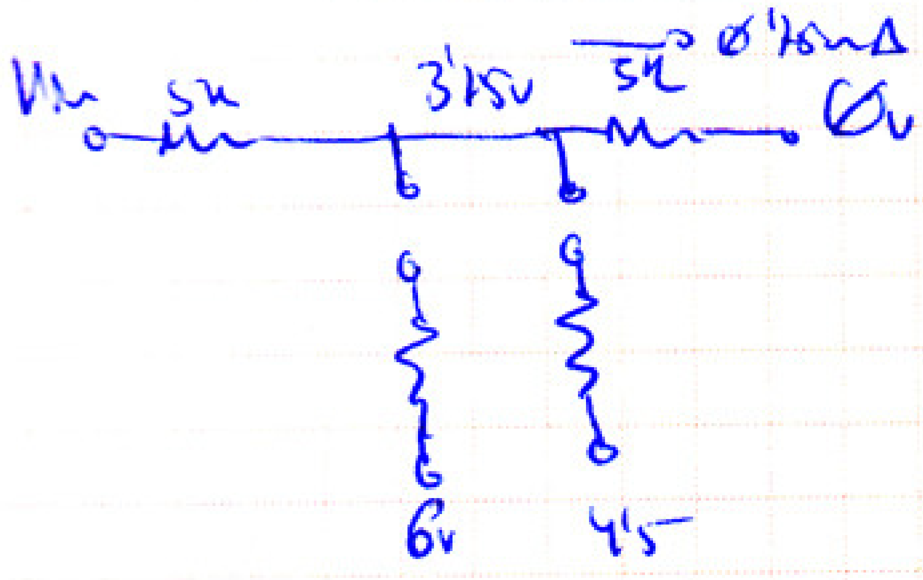
$0'75mA + 8'25mA = 9mA$ $9mA \cdot 5k = 45$

$V_{in} = -3'75 - 45 = \boxed{-48'75v}$

Punto crítico D33

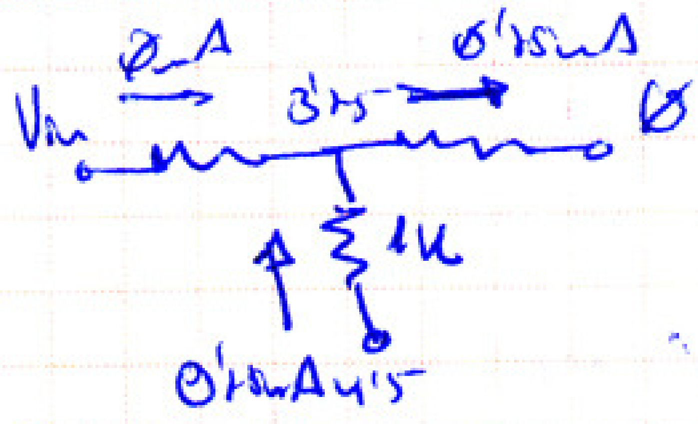
$I_{R8} = \frac{5}{20k} = 0'25\,mA$ $\quad V_0 = -10 + 0'25mA \cdot 10k = -7'5\,V$ $\quad I_{R7} = 7'5V / 10k = 0'75\,mA$

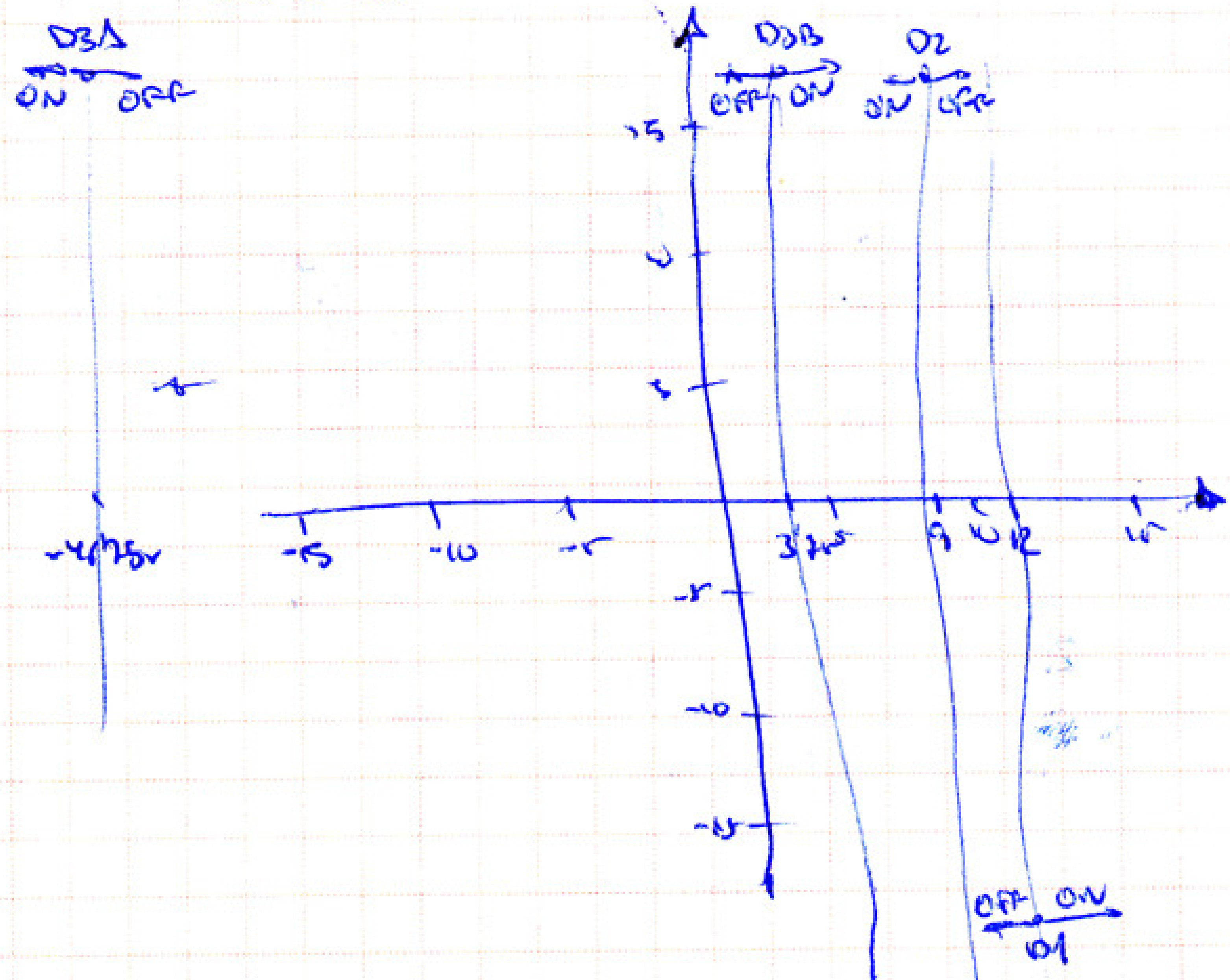
$I_{R6} = 0'75\,mA$ $\quad V_A = 0'75mA \cdot 5k = 3'75\,V$



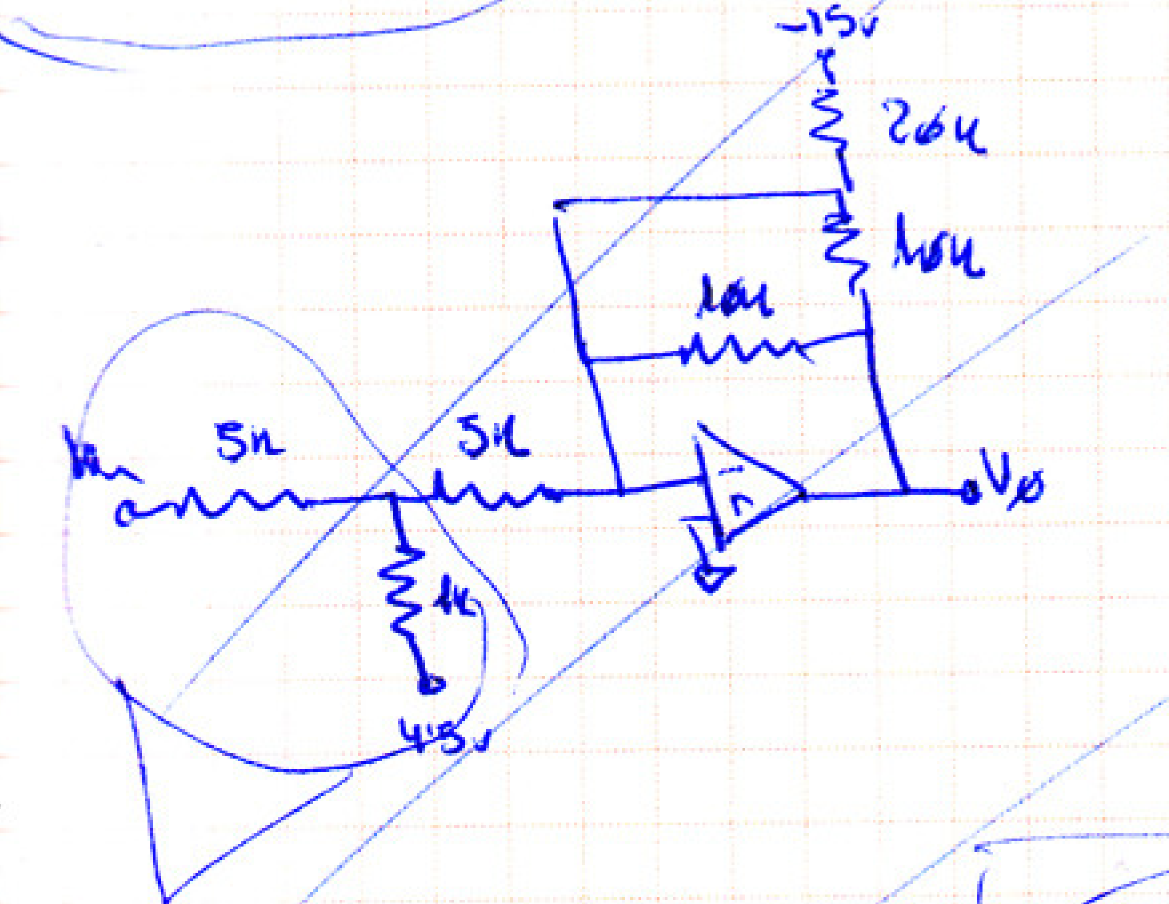
D1 OFF D2 ON

$\boxed{V_{in} = 3'75\,V}$





$-15 < V_{in} < 3'25$ D3A, D2 ON



$V_0 = (-15)\left(-\frac{5k}{20k}\right) + \left(+\frac{V_{in}}{6} + 3'25\right)\left(-\frac{5k}{35/6\,k}\right)$ $\quad \frac{30}{35} = \frac{6}{7}$

$= \frac{15}{4} - \frac{30}{42} V_{in} - \frac{22'5}{7}$

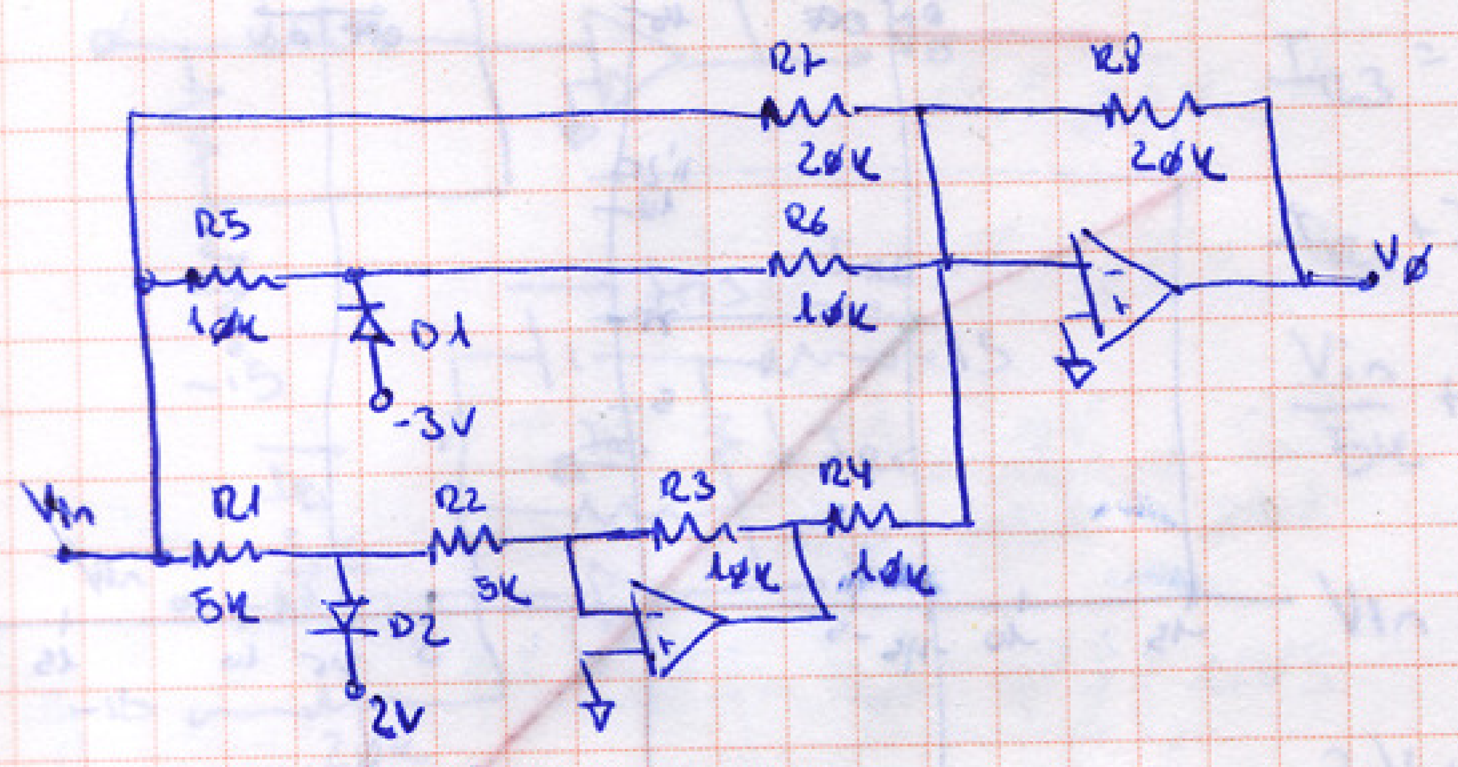
$= -\frac{V_{in}}{7} + \frac{105}{28} - \frac{90}{28} = -\frac{V_{in}}{7} + \frac{15}{28}$

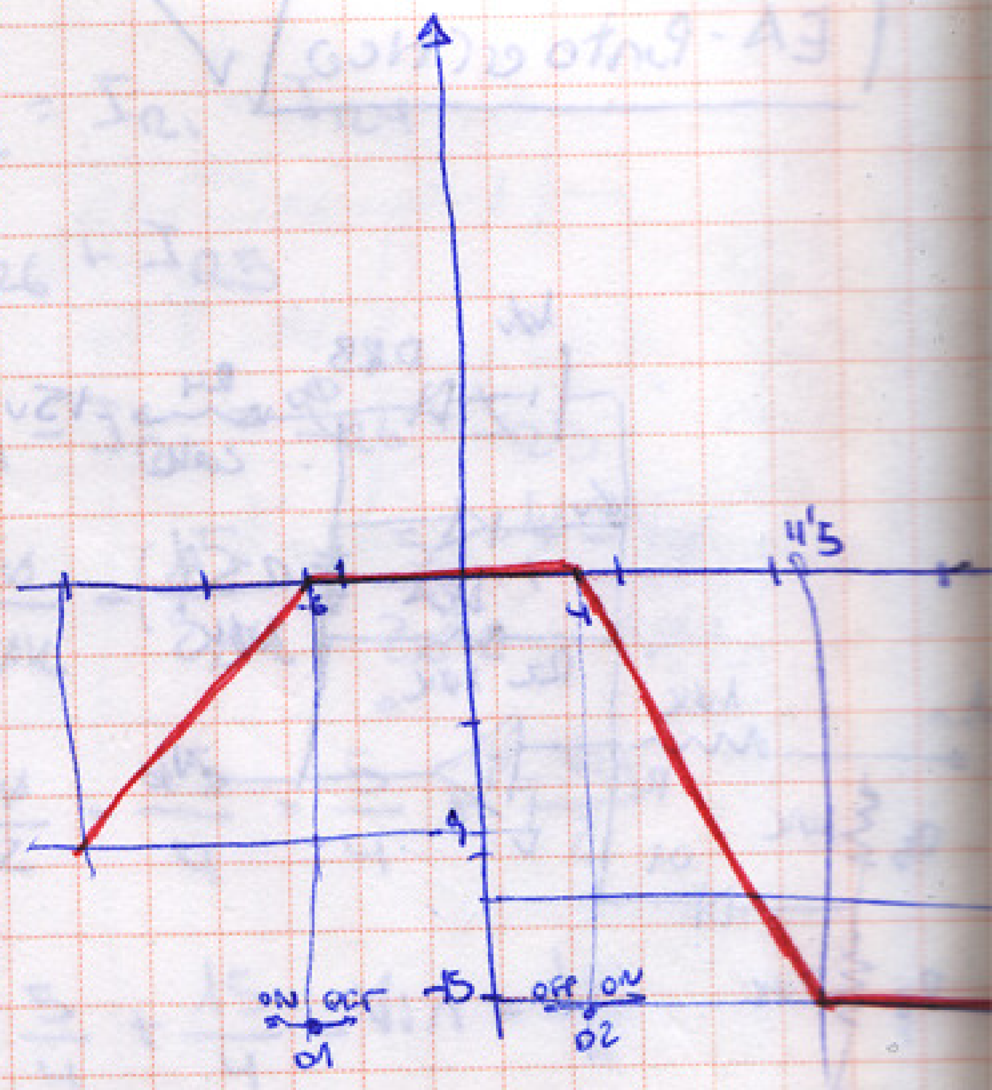
$3'25 < V_{in} < 9$ D

$V_{in} - \left(\frac{V_{in} - 4'5v}{6k} \cdot 5k\right) = \frac{V_{in}}{6} + 3'75$

C

EA - Punto crítico ✓





Punto crítico D1

$I_{R6} = \frac{3V}{10k} = 0'3mA$ $I_{R5} = I_{R6}$ $V_{in} = -3V - 0'3mA \cdot 10k = \boxed{-6V}$

D2: OFF Porque tendrá tensión negativa en su ánodo y positiva en el cátodo.

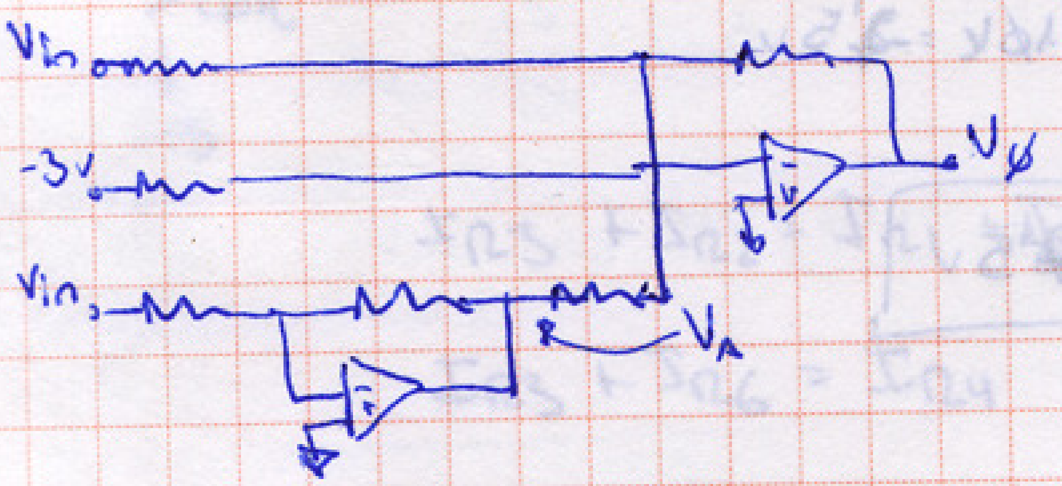
Punto crítico D2

$I_{R2} = \frac{2V}{5k} = 0'4mA$ $I_{R1} = I_{R2}$ $V_{in} = 2 + 0'4mA \cdot 5k = \boxed{4V}$

D1: OFF Porque tendrá tensión positiva en el cátodo y negativa en el ánodo.

$-15 < V_{in} < -6V$ D1: ON

$V_A = V_{in}\left(-\frac{10k}{10k}\right)$



$V_0 = V_{in}\left(-\frac{20k}{20k}\right) + (-3)\left(-\frac{20k}{10k}\right) + (-V_{in})\left(-\frac{20k}{10k}\right)$

$V_0 = -V_{in} + 6 + 2V_{in} = \boxed{V_{in} + 6}$

$-15 = V_{in} + 6 \rightarrow V_{in} = -21$ ∄ No hay saturación

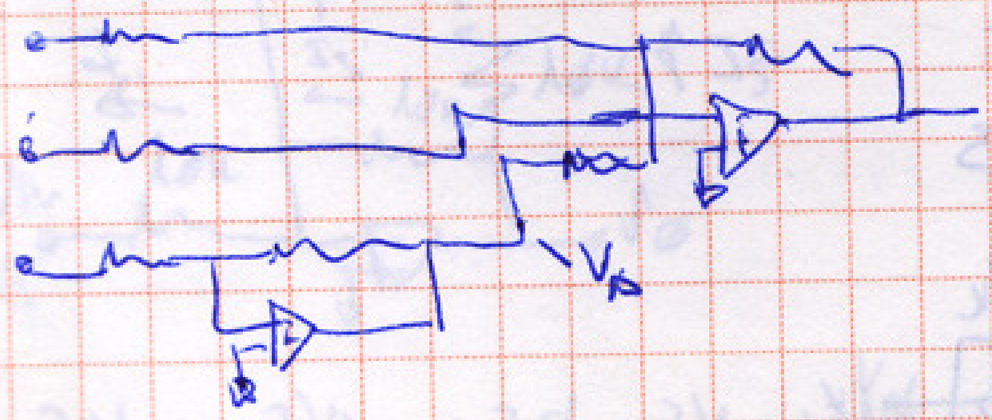
$V_0 = -15 + 6 = -9V$

$V_0 = -6 + 6 = 0V$

$-6 < V_{in} < 4V$

$V_A = V_{in}\left(-\frac{10k}{10k}\right)$

$V_0 = V_{in}\left(-\frac{20k}{20k}\right) + V_{in}\left(-\frac{20k}{20k}\right) - V_{in}\left(-\frac{20k}{10k}\right) = \boxed{0V}$



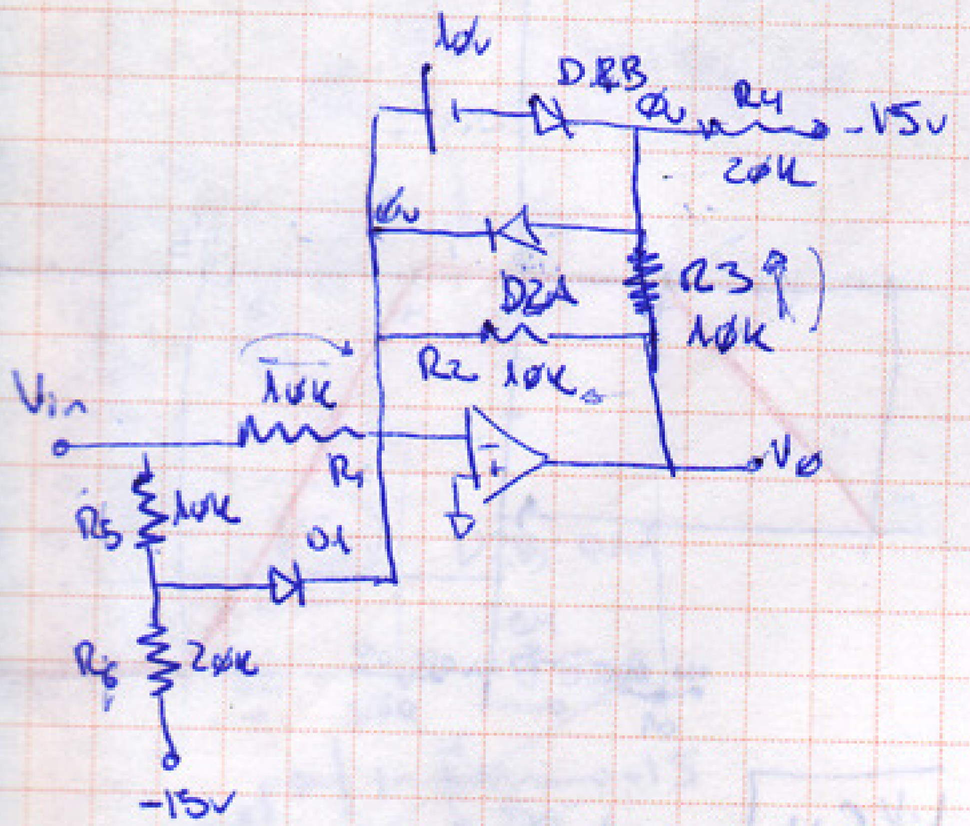
$4 < V_{in} < 15$ D2: ON

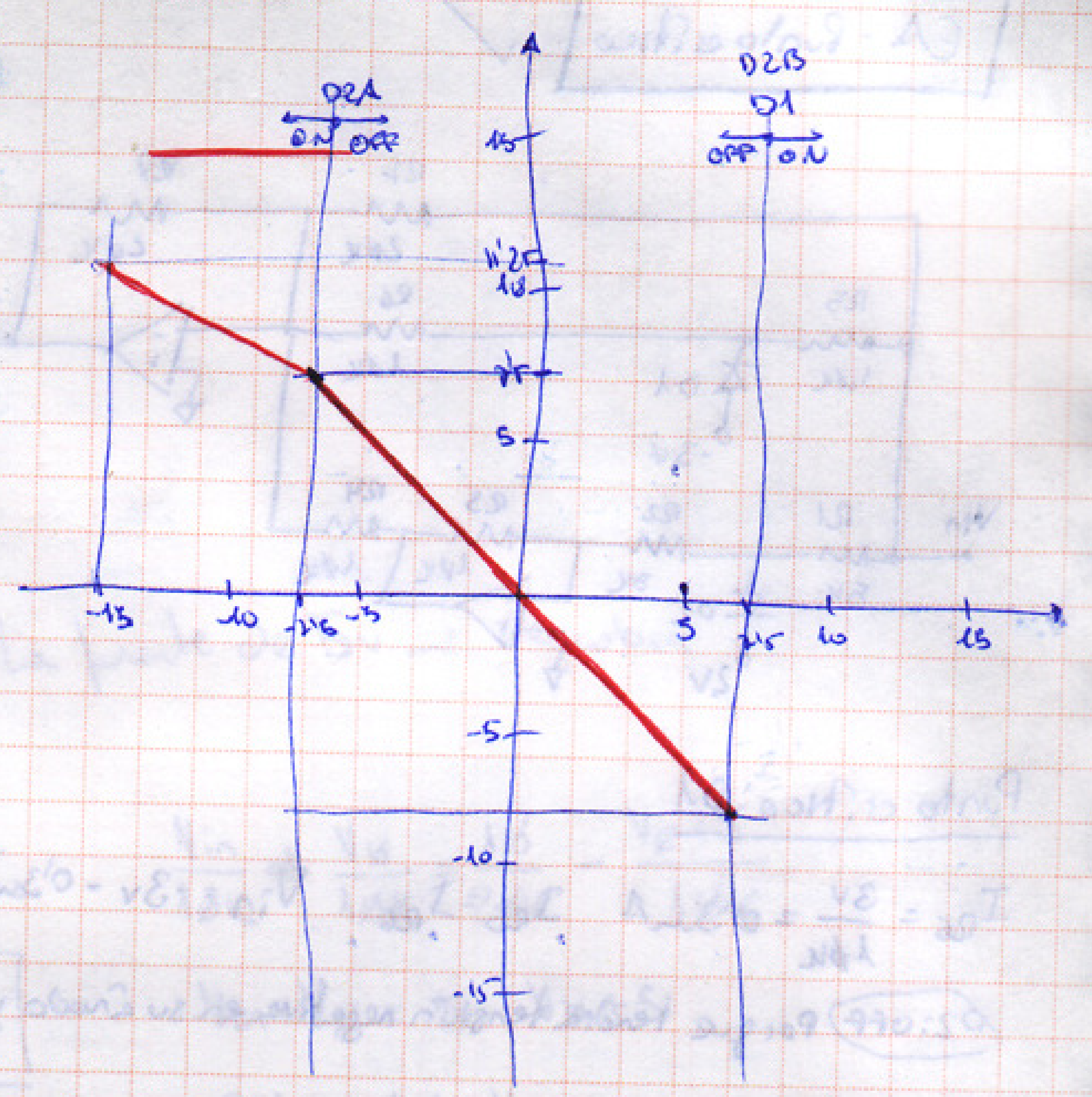
$V_A = 2\left(-\frac{10k}{5k}\right)$

$V_0 = -V_{in} - V_{in} - 4\left(-\frac{20k}{10k}\right) = \boxed{-2V_{in} + 8V}$

$-15 = -2V_{in} + 8 \rightarrow V_{in} = \frac{23}{2} = 11'5$ ∃ Hay saturación

EA - Punto crítico ✓





Punto crítico D1

$V_{in} = \frac{15V}{20k} \cdot 10k = \boxed{7'5V}$

Punto crítico D2A

D2B: OFF

$I_{R4} = \frac{15}{20k} = 0'75\,mA$

$I_{R2} = \frac{7'5}{10k} = 0'75\,mA$

Suponemos D1: OFF

$V_{in} = -0'75 \cdot 10k = \boxed{-7'5}$

$I_{R3} = I_{R4}$ $V_\emptyset = 0'75\,mA \cdot 10k = 7'5V$

Punto crítico D2B

D2A: OFF

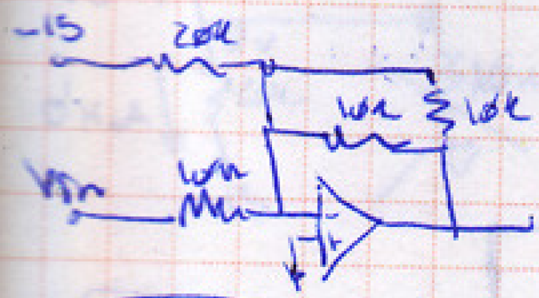
$I_{R4} = \frac{5V}{20k} = 0'25\,mA$ $I_{R3} = I_{R4}$ $V_\emptyset = -10 + 0'25\,mA \cdot 10k = -7'5V$

$I_{R2} = \frac{2'5}{10k} = 0'25\,mA$

Suponemos D1: OFF

$V_{in} = 0 + 0'25\,mA \cdot 10k = \boxed{2'5V}$

$-15 < V_{in} < -7'5$ D2A ON



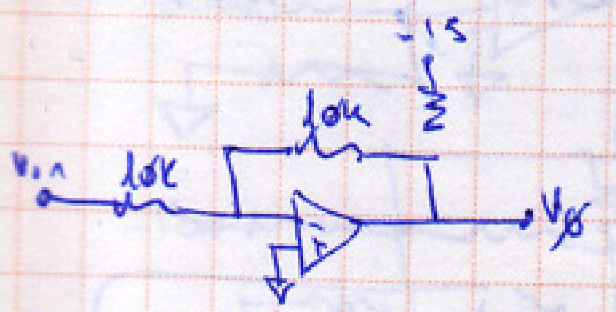
$$V_\emptyset = V_{in}\left(-\frac{5k}{10k}\right) + (-15)\left(-\frac{5k}{20k}\right) = -\frac{V_{in}}{2} + \frac{15}{4} = \boxed{\frac{-V_{in}+7'5}{2}}$$

$15 = \frac{-V_{in}+7'5}{2} \Rightarrow V_{in} = -22'5$ ¡Nunca se satura!

$V_\emptyset = \frac{-(-15)+7'5}{2} = 11'25V$

$V_\emptyset = \frac{-(-7'5)+7'5}{2} = 7'5V$

$-7'5 < V_{in} < 7'5$

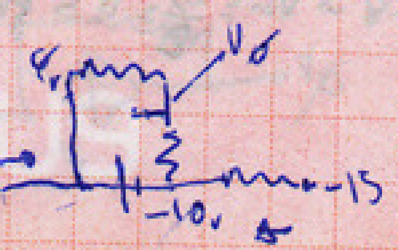


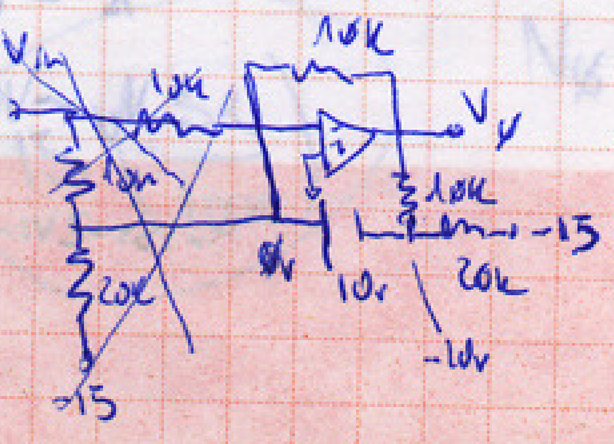
$\boxed{V_\emptyset = -V_{in}}$

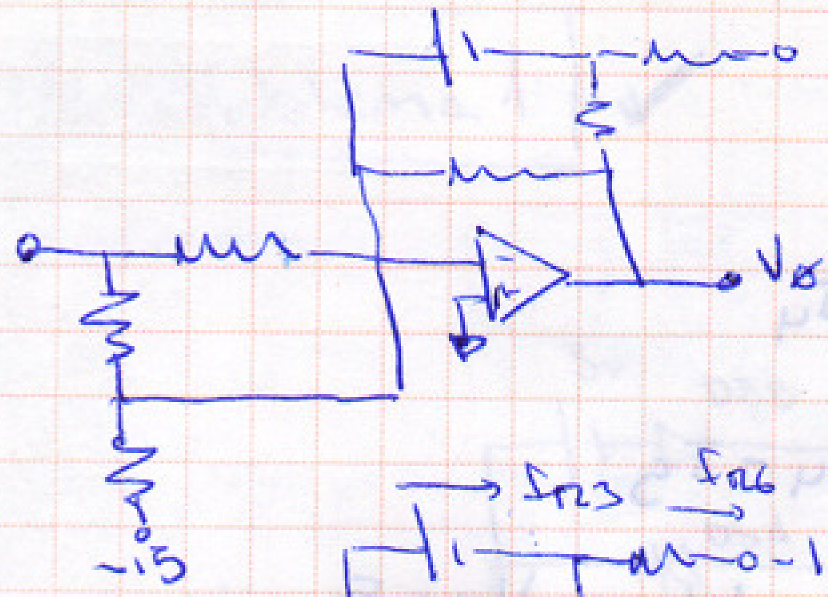
$V_\emptyset = 7'5$

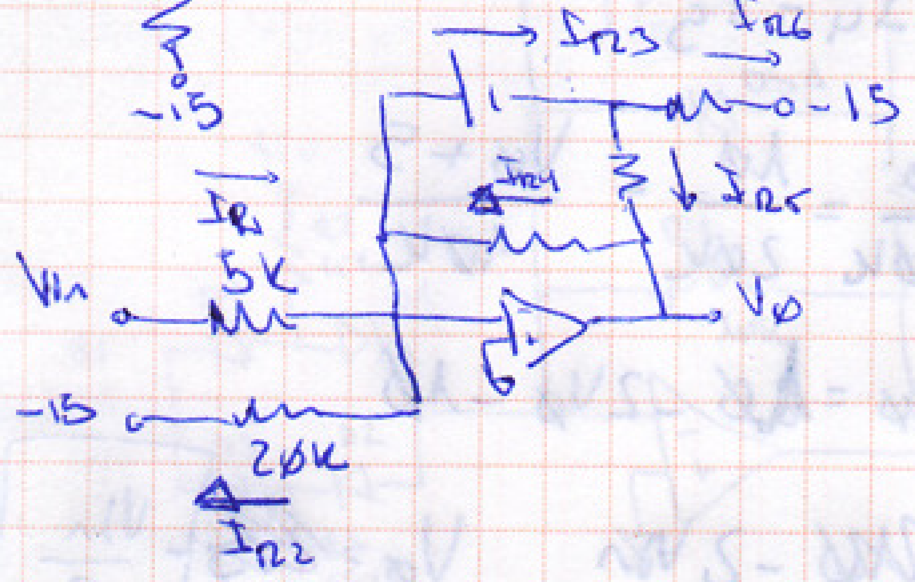
$V_\emptyset = -7'5$

$7'5 < V_{in} < 15$ D2B, D1 ON









$I_{R3} + I_{R2} = I_{R1} + I_{R4}$

$I_{R3} = I_{R6} + I_{R5}$

$I_{R1} + I_{R4} - I_{R2} = I_{R6} + I_{R5}$

$\frac{V_{in}}{5k} + \frac{V_\emptyset}{10k} - \frac{15}{20k} = \frac{5}{20k} + \frac{10 - V_\emptyset}{10k}$

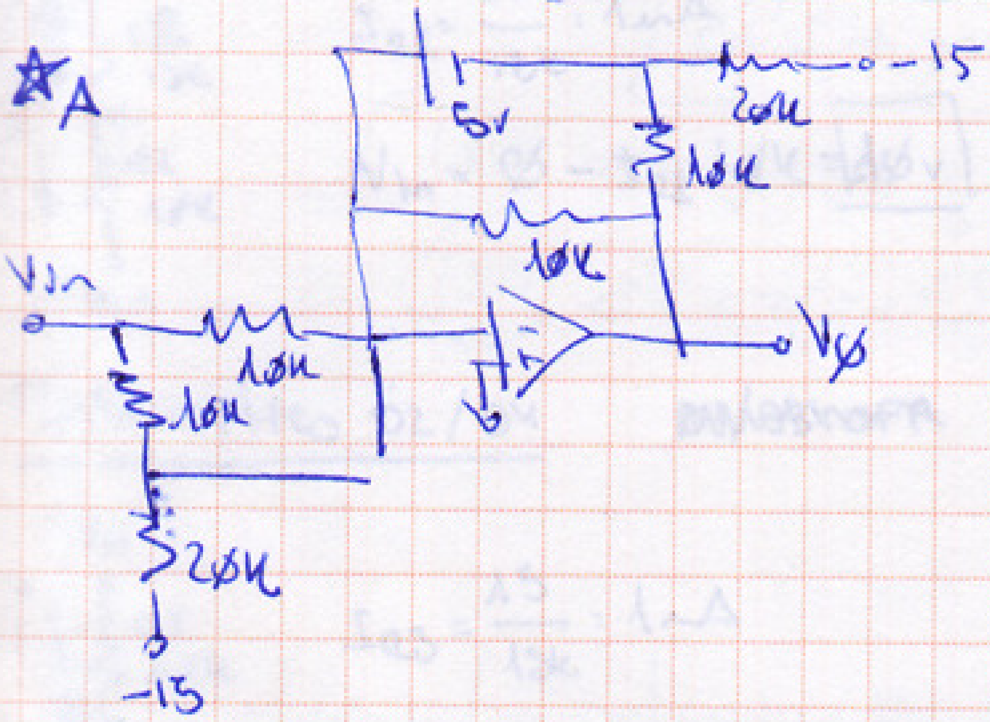
$V_{in} + \frac{V_\emptyset}{2} - \frac{15}{4} = \frac{5}{4} + \frac{10 - V_\emptyset}{2}$

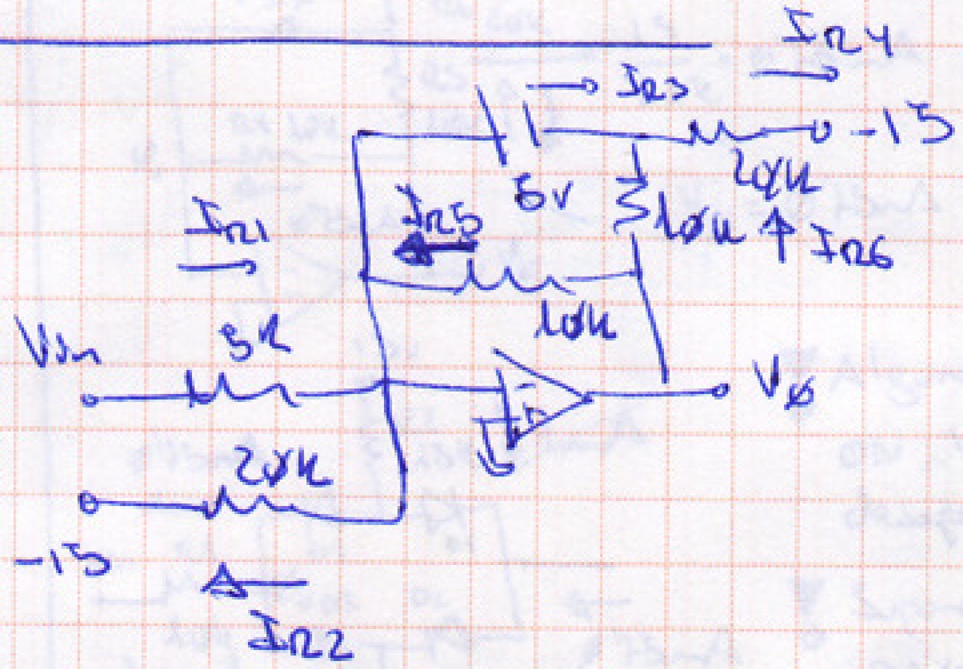
$\frac{2V_\emptyset}{2} = \frac{5}{4} + \frac{15}{4} - V_{in} - \frac{10}{2}$

~~$4V_{in} + 2V_\emptyset - 15 = 5 + 2V_\emptyset$~~

~~$4V_\emptyset = 20 - 4V_{in}$~~ $\longrightarrow$ $\boxed{V_\emptyset = [illegible] - V_{in}}$

★A





$I_{R3} + I_{R2} = I_{R1} + I_{R5}$

$I_{R3} + I_{R6} = I_{R4}$

$I_{R1} + I_{R5} - I_{R2} = I_{R4} - I_{R6}$

$\frac{V_{in}}{5k} + \frac{V_\emptyset}{10k} - \frac{15}{20k} = \frac{10}{20k} - \frac{V_\emptyset + 5}{10k}$

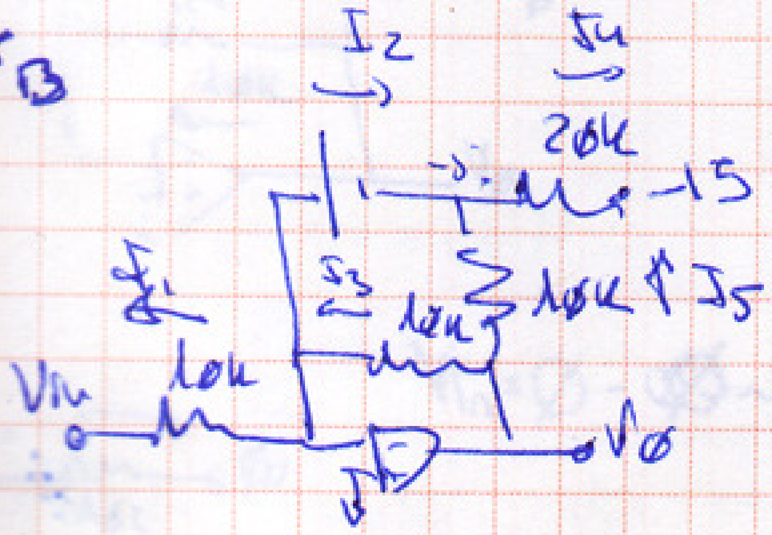
$4V_{in} + 2V_\emptyset - 15 = \cancel{10} - 2V_\emptyset + \cancel{10}$

$4V_\emptyset = 15 - 4V_{in}$ $\quad \boxed{V_\emptyset = 3'75 - V_{in}}$

$V_\emptyset = -3'75$

$V_\emptyset = -11'25$

★B



$I_1 + I_2 = I_3$

$I_2 + I_5 = I_4$

$I_3 - I_1 = I_4 - I_5$

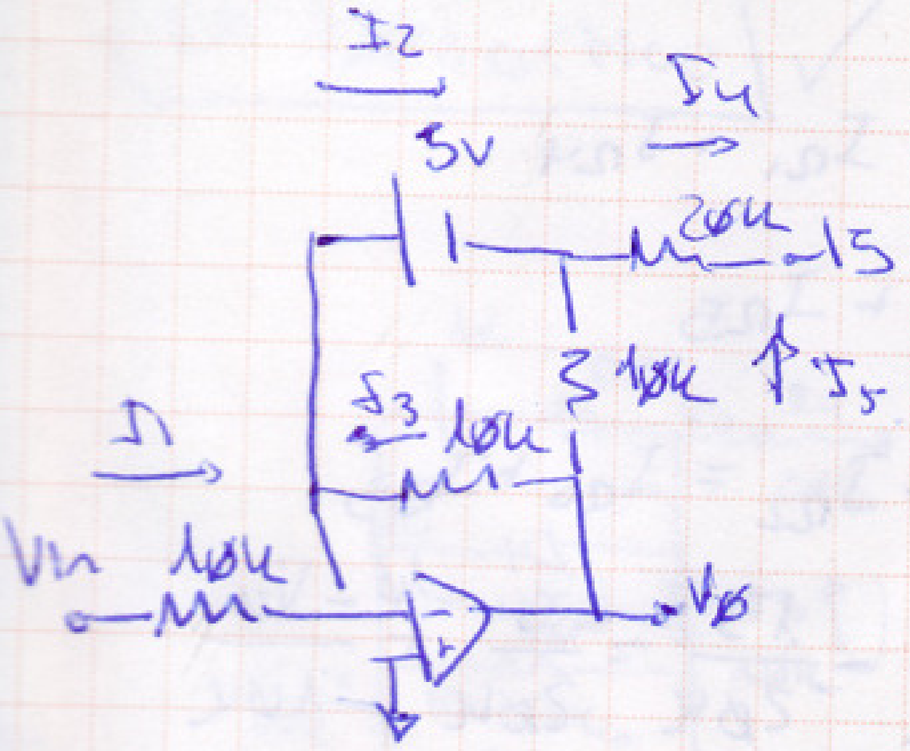
~~$I_3 - I_1 = I_4 - I_2$~~

~~$\frac{V_\emptyset}{10k} - \frac{V_{in}}{10k} = \frac{10}{20k}$~~

$\frac{V_\emptyset}{10k} + \frac{V_{in}}{10k} = \frac{10}{20k} - \frac{V_\emptyset - 5}{10k}$

$2V_\emptyset + 2V_{in} = 20 - 2V_\emptyset + 10$

$4V_\emptyset = 30 - 2V_{in}$ $\quad V_\emptyset = 7'5 - V_{in}/2$



$V_\emptyset = 2'5$

$V_\emptyset = 3'25$

$I_1 + I_3 = I_2$

$I_2 + I_5 = I_4$

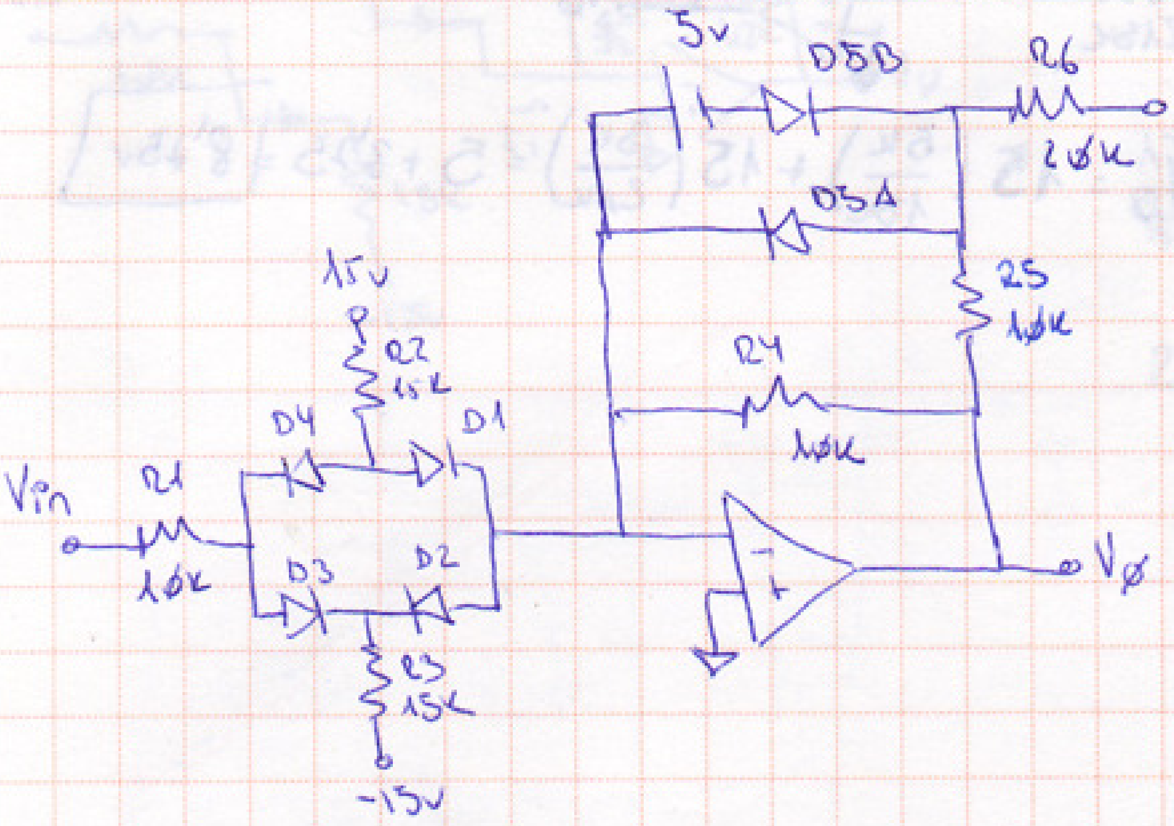
$I_1 + I_3 = I_4 - I_5$

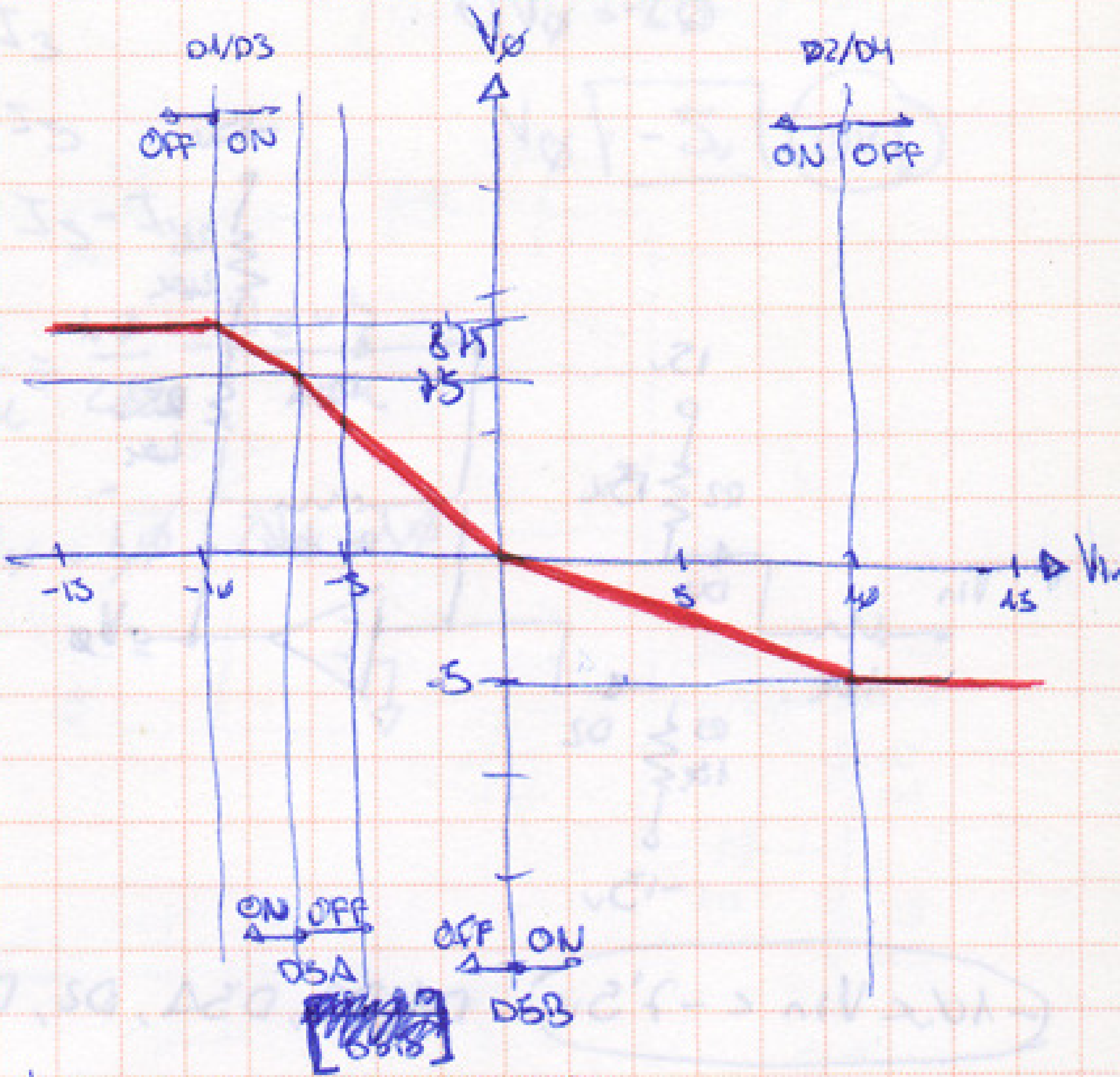
$$\frac{V_{in}}{10k} + \frac{V_\emptyset}{10k} = \frac{10}{20k} - \frac{V_\emptyset + 5}{10k}$$

$2V_{in} + 2V_\emptyset = 10 - 2V_\emptyset - 10$

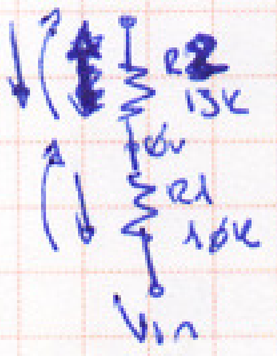
$4V_\emptyset = \cancel{5}\,10 - 2V_{in}$ $\quad V_\emptyset = \cancel{2,5}\ \boxed{-\frac{V_{in}}{2}}$

EA - Problema 1 ✓





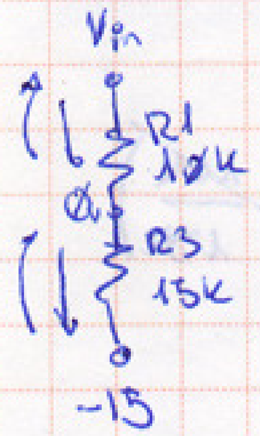
Punto crítico D1/D3



$I_{R2} = \frac{15}{15k} = 1mA$

$V_{in} = \varnothing - I_{R2} \cdot 10k = \boxed{-10v}$

Punto crítico D2/D4

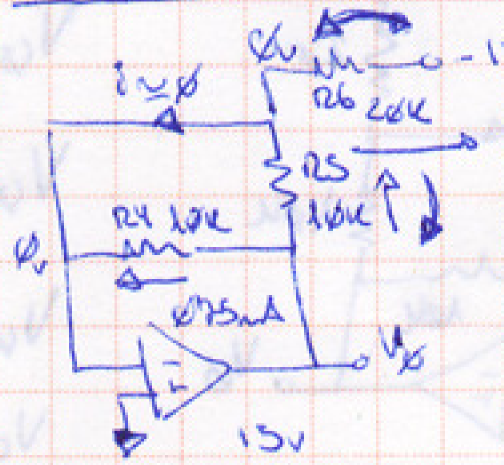


$I_{R3} = \frac{15}{15k} = 1mA$

$V_{in} = I_{R3} \cdot 10k \boxed{10v}$

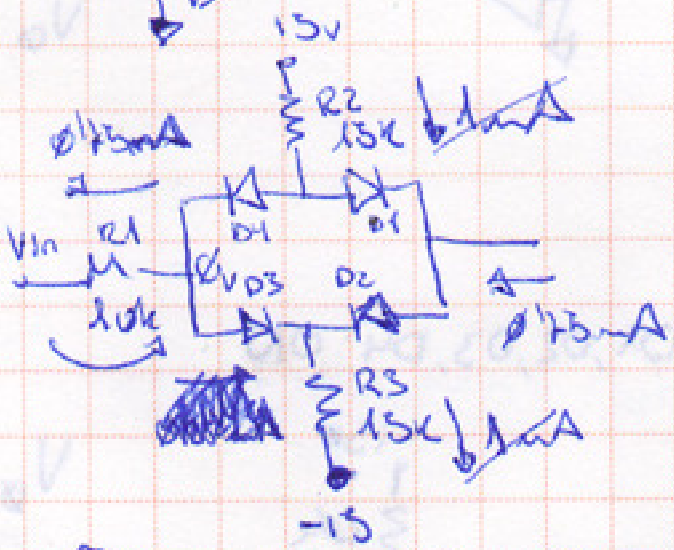
Punto crítico D5A

D5B: OFF



$\frac{15}{20k} = 0'75mA$

$V_\varnothing = 0'75mA \cdot 10k = 7'5v$



Suponemos todos ON

$V_{in} = \varnothing - 0'75mA \cdot 10k \boxed{-7'5v}$

Alguno tiene que estar ON, la corriente no puede desaparecer.

Suponemos D1/D3 ON y D2/D4 OFF

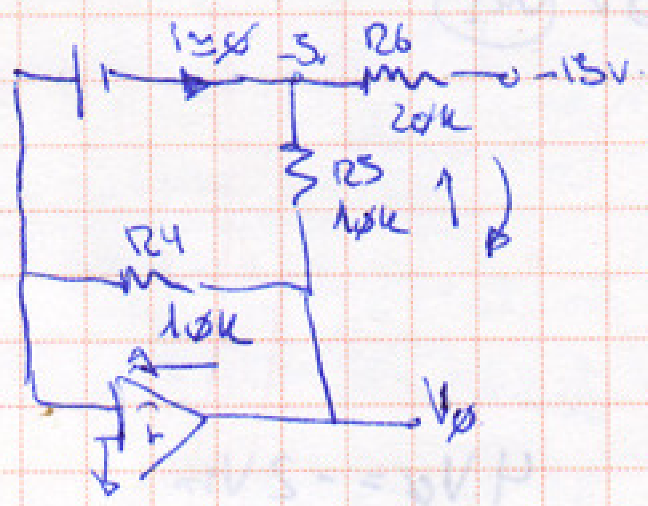
$I_{R2} = 1mA$ en dirección contraria, no puede ser

Suponemos D2/D4 ON y D1/D3 OFF

$I_{R3} = 1mA$, nos faltan 0'25mA, no puede ser

Punto crítico D5B

D5A: OFF



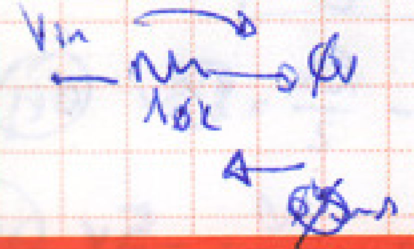
$I_{R6} = \frac{10}{20k} = 0'5mA$

$I_{R5} > I_{R6}$

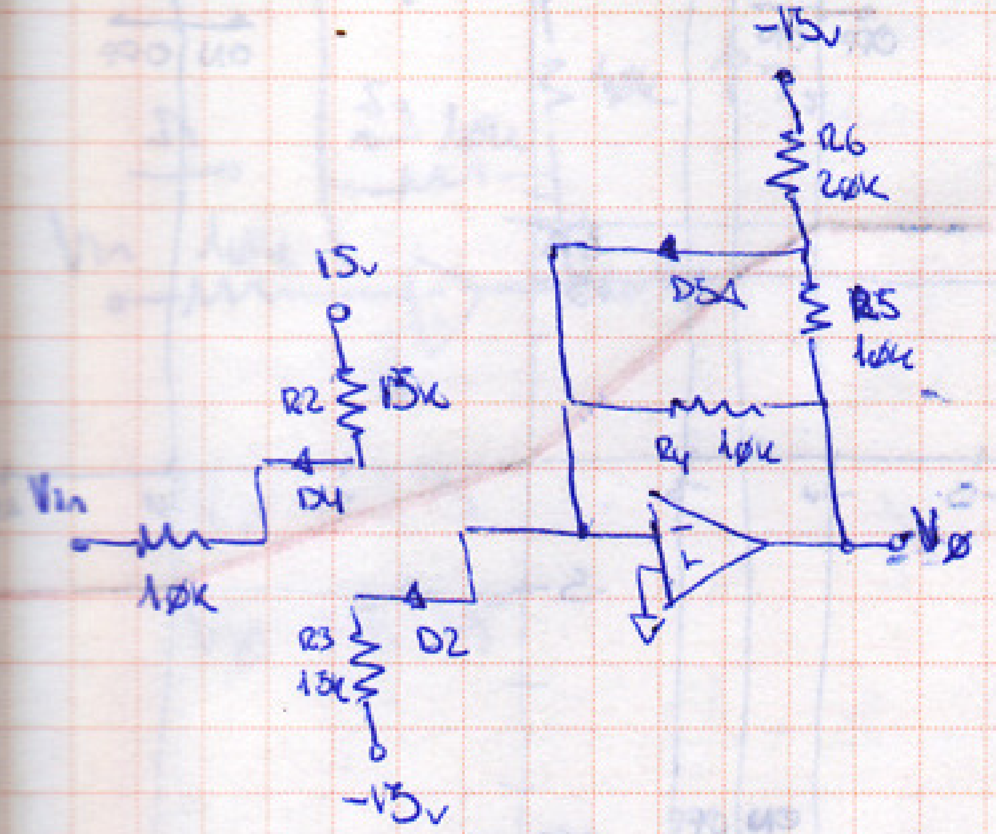
$V_\varnothing = 0'5mA \cdot 10k = 5V$ -5v

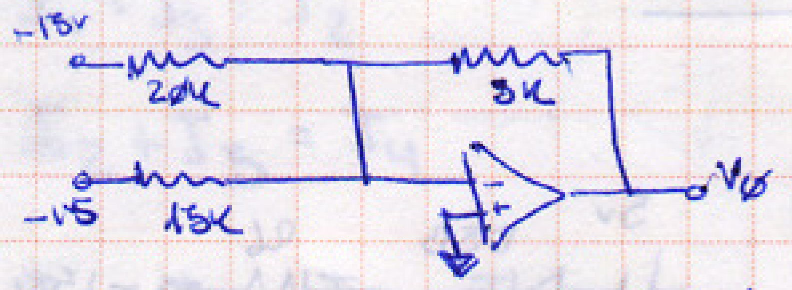
$I_{R4} = \frac{5v}{10k} = 0'5mA$

$V_{in} = \varnothing - \cancel{\varnothing}mA \cdot 10k = \boxed{\cancel{\varnothing}v}$



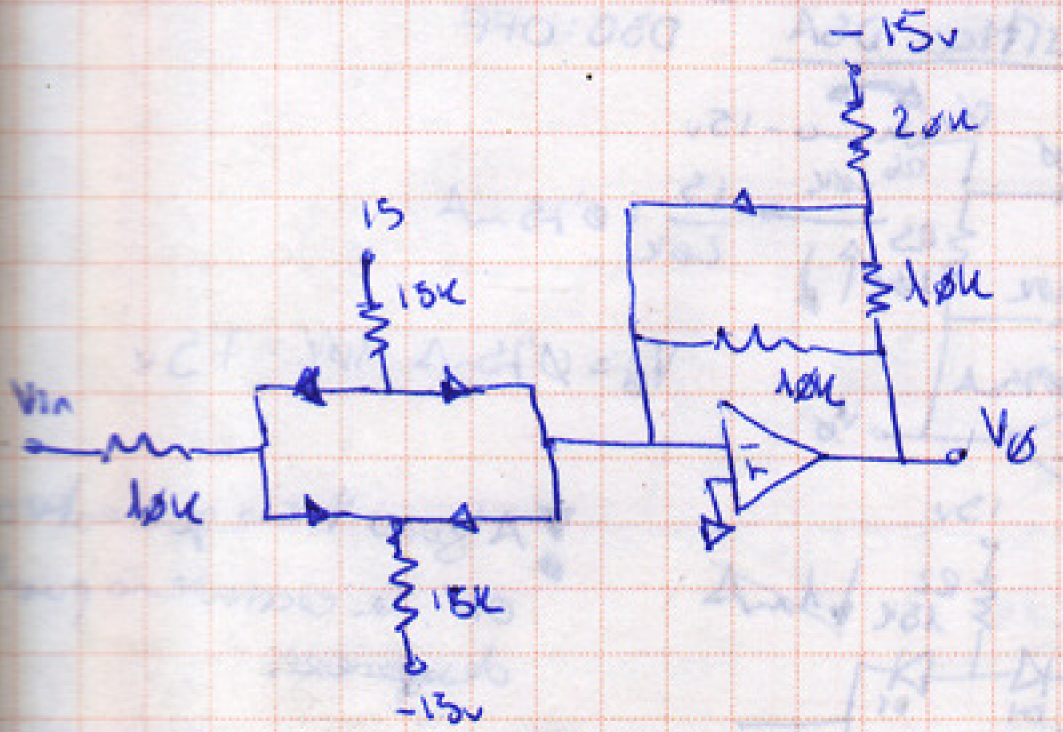
$-15 < V_{in} < -10$ D51, D8, D4: ON





$$V_o = 15\left(\frac{5k}{15k}\right) + 15\left(\frac{5k}{20k}\right) = 5 + 3'75 = \boxed{8'75v}$$

$-10 < V_{in} < -7'5v$ D1, D3, D51, D2, D4: ON



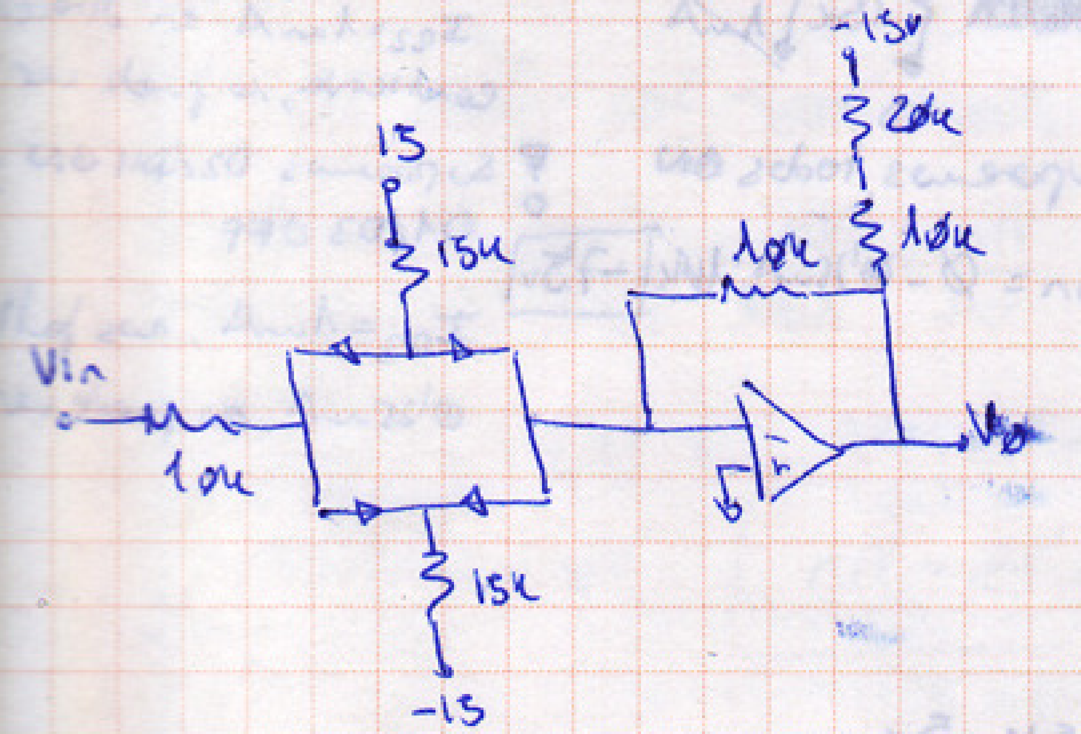
$$V_o = V_{in}\left(-\frac{5k}{10k}\right) + \cancel{15\left(-\frac{5k}{15k}\right) + (-15v)\left(-\frac{5k}{15k}\right)} + (-15v)\left(-\frac{5k}{20k}\right)$$

$$V_o = \boxed{-\frac{V_{in}}{2} + 3'75}$$

$$V_o = -\frac{-10}{2} + 3'75 = 8'75 \quad \text{Ok!}$$

$$V_o = -\frac{-7'5}{2} + 3'75 = 7'5 \quad \text{Ok!}$$

$-7'5v < V_{in} < 0$ D1, D2, D3, D4: ON



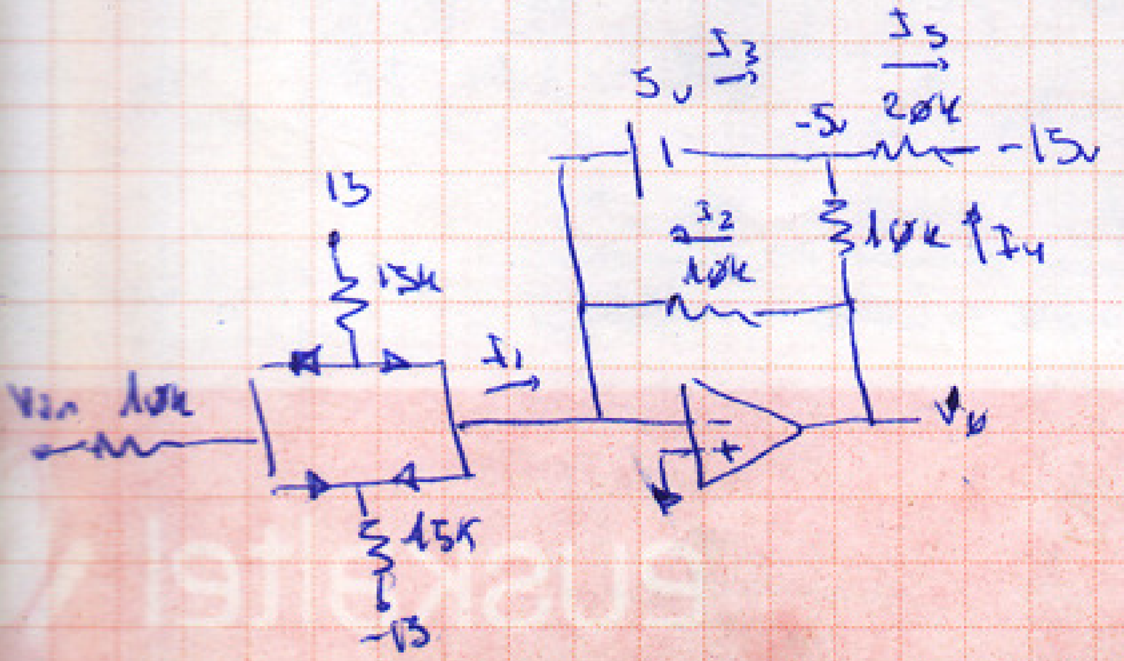
$$V_o = V_{in}\left(-\frac{10k}{10k}\right) + \cancel{(-15)\left(-\frac{10k}{15k}\right) + (-15)\left(-\frac{10k}{15k}\right)}$$

$$V_o = \boxed{-V_{in}}$$

$$V_o = -(-7'5) = 7'5v \quad \text{Ok!}$$

$$V_o = -(0) = 0v \quad \text{Ok!}$$

$0v < V_{in} < 10$ D1, D3, D2B, D2, D4: ON



$$I_3 = I_1 + I_2$$

$$I_3 + I_4 = I_5$$

$$I_1 + I_2 = I_5 - I_4$$

$$\frac{V_{in}}{10k} + \frac{V_o}{10k} = \frac{10}{20k} - \frac{V_o + 5}{10k}$$

$$2V_{in} + 2V_o = \cancel{10} - 2V_o - \cancel{10}$$

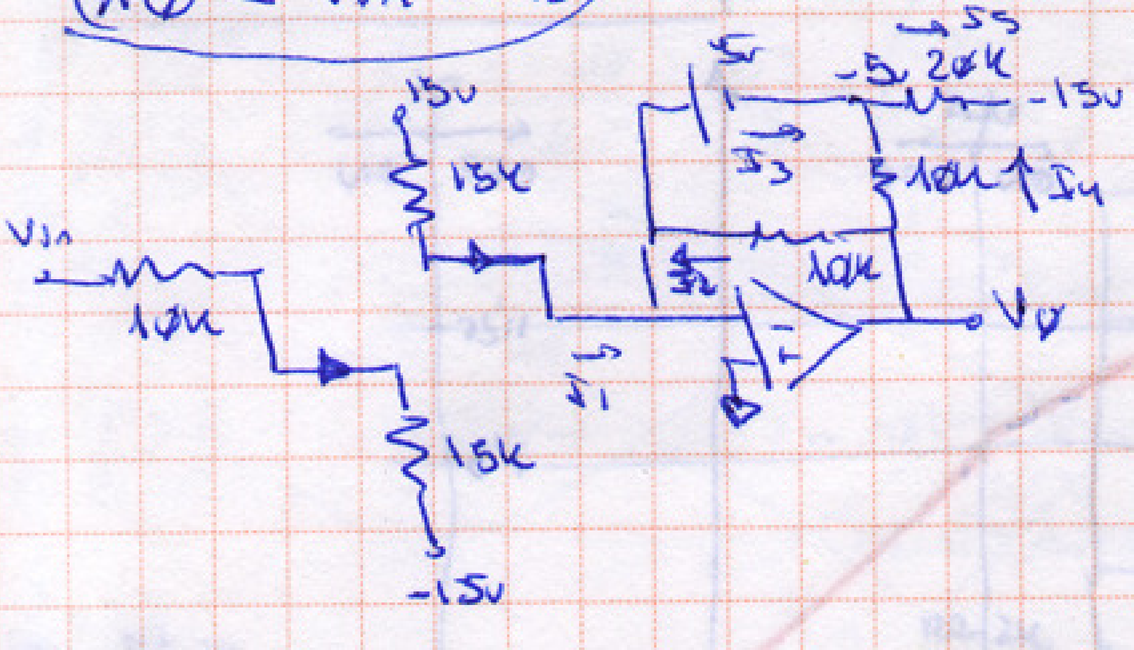
$$4V_o = -2V_{in}$$

$$V_o = \boxed{-\frac{V_{in}}{2}}$$

$$V_o = -\frac{0v}{2} = 0v \quad \text{Ok!}$$

$$V_o = -\frac{10}{2} = -5v \quad \text{Ok!}$$

$10 < V_{in} < 15$ D1, D3, D5B: ON



$I_1 + I_2 = I_3$

$I_3 + I_4 = I_5$

$I_1 + I_2 = I_3 - I_4$

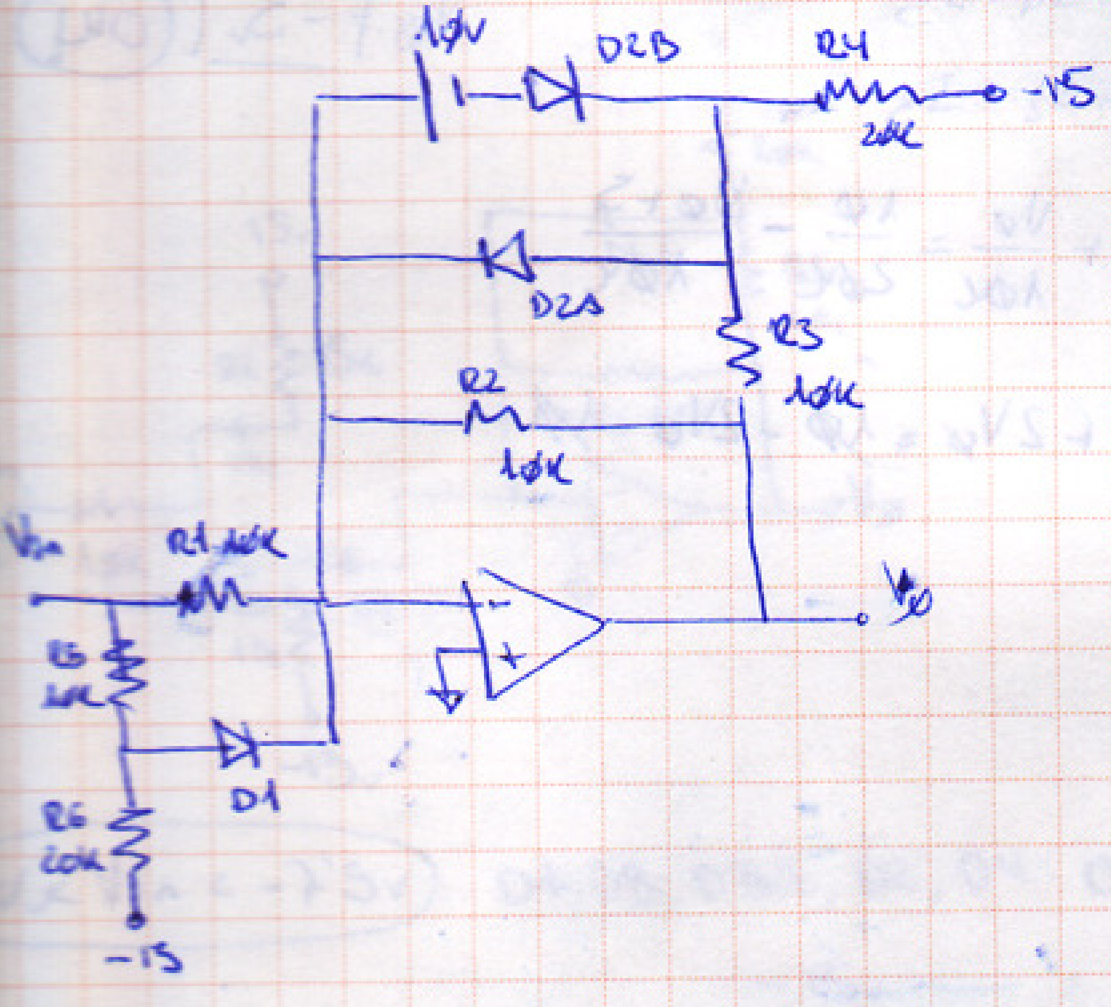
$$\frac{15}{15k} + \frac{V_\phi}{10k} = \frac{10}{20k} - \frac{V_\phi + 5}{10k}$$

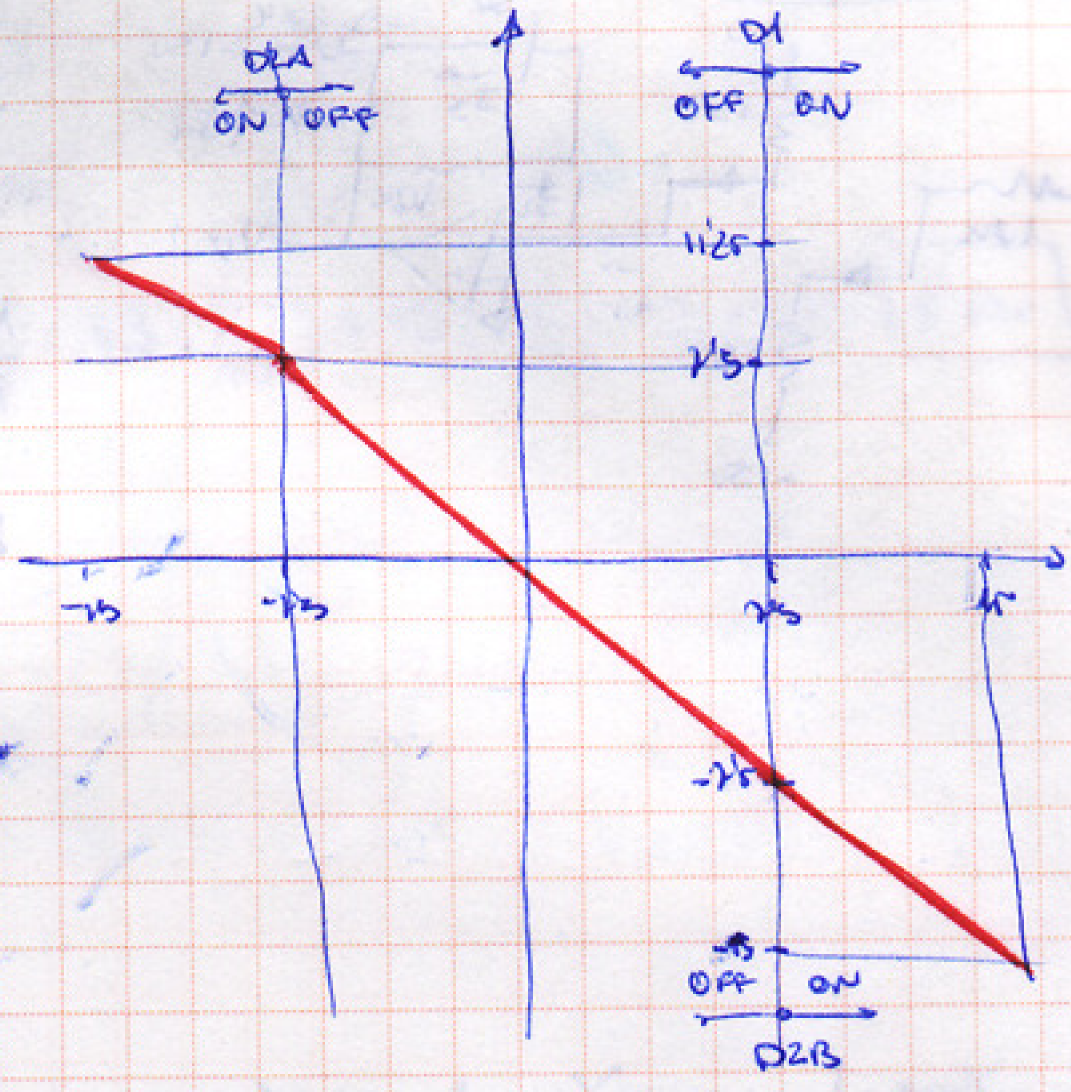
$$20 + 2V_\phi = \cancel{10} - 2V_\phi - \cancel{10}$$

$4V_\phi = -20$

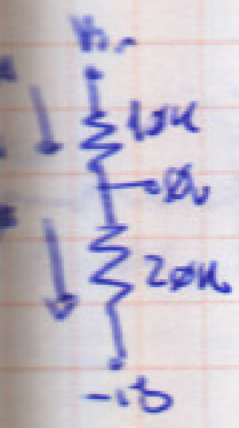
$V_\phi \boxed{= -5}$ OK!

EA - Punto crítico ✓





Punto crítico D1



$V_{in} = \frac{15v}{20k} \cdot 10k = 7'5v$

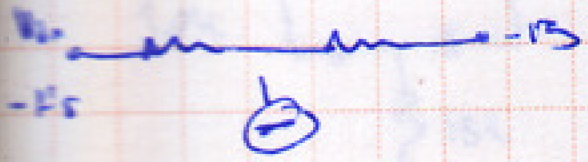
Punto crítico D2A

$I_{R4} = \frac{15v}{20k} = 0'75mA \qquad V_o = 0'75mA \cdot 10k = 7'5v$

$I_{R2} = \frac{7'5v}{10k} = 0'75mA$

Suponemos D1 OFF

$V_{in} = -0'75mA \cdot 10k = -7'5v$ (ok)



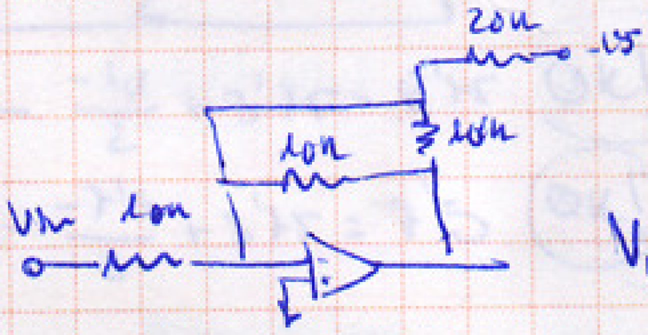
Punto crítico D2B

$I_{R4} = \frac{5v}{20k} = 0'25mA \quad I_{R3} = I_{R4} \quad V_o = -10 + 0'25mA \cdot 10k = -7'5V$

$I_{R2} = \frac{7'5v}{10k} = 0'75mA \quad V_{in} = 0'75mA \cdot 10k = 7'5V$ si D1 OFF

$-\left(\frac{7'5+15}{30k} \cdot 10k\right) + 7'5 = 0$ (ok)

$-15 < V_{in} < -7'5$ D2A ON

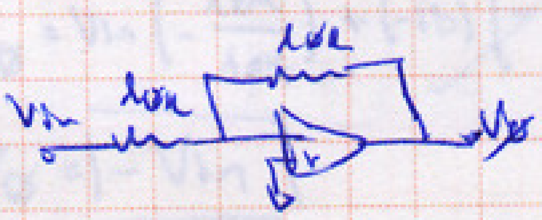


$V_o = -\frac{V_{in}}{2} + \frac{15}{4}$

$= \boxed{-\frac{V_{in}}{2} + 3'75}$

$V_{in} \rightarrow [11'25, 7'5]$ (ok!)

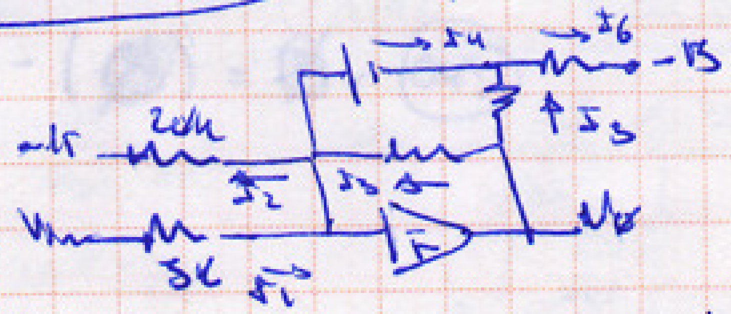
$-7'5 < V_{in} < 7'5$



$\boxed{V_o = -V_{in}}$

$V_{in} \rightarrow [7'5, -7'5]$ (ok!)

$7'5 < V_{in} < 15$ D1, D2B ON



$I_1 - I_2 + I_3 - \cancel{I_4} = 0 = I_6 - I_5 - \cancel{I_4}$

$\cancel{I_1 + I_3 - I_2 - I_4 = 0}$

$I_1 - I_2 + I_3 = I_6 + I_5$

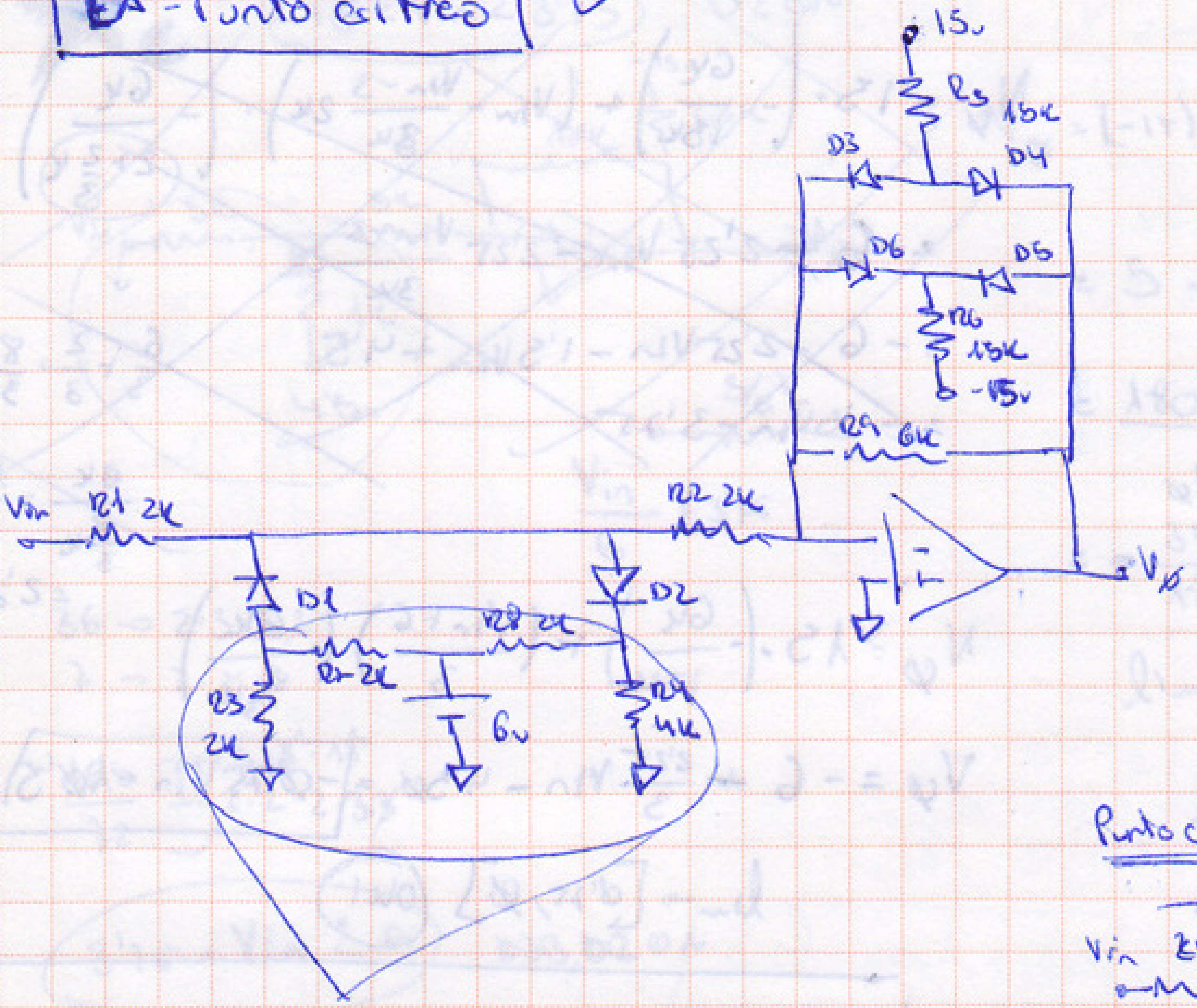
$\frac{V_{in}}{5k} - \frac{15}{20k} + \frac{V_o}{10k} = \frac{5}{20k} - \frac{(V_o + 10)}{10k}$

$4V_{in} - 15 + 2V_o = 5 - 2V_o - 20$

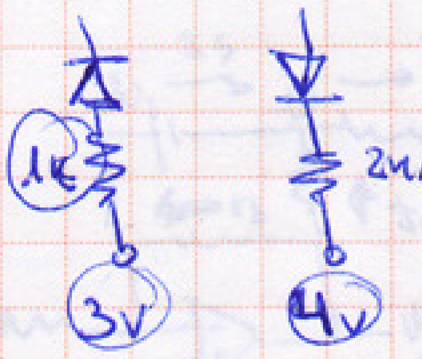
$4V_o = -4V_{in} \quad \boxed{V_o = -V_{in}}$

$V_{in} \rightarrow [-7'5, -15]$ (ok!)

E1 - Punto crítico

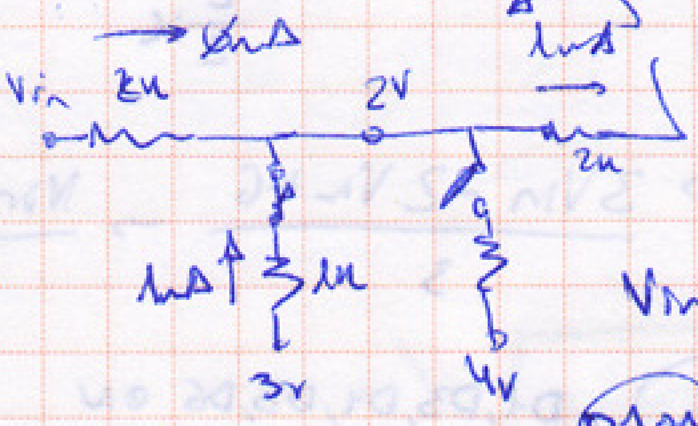


$6 = x + 2k \rightarrow x = 2$



$2k // 4k = \frac{8}{6} k = \frac{4}{3} k$

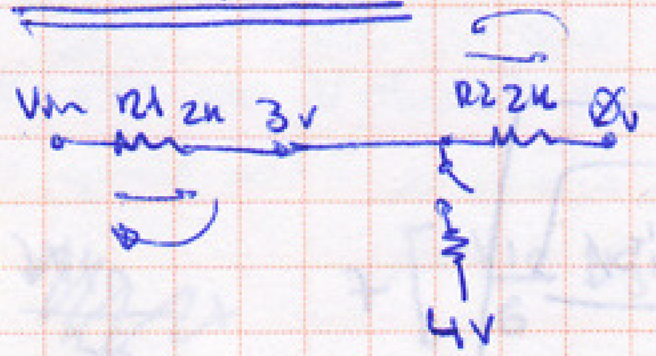
Punto crítico D3/D5



$V_{in} = \boxed{2V}$

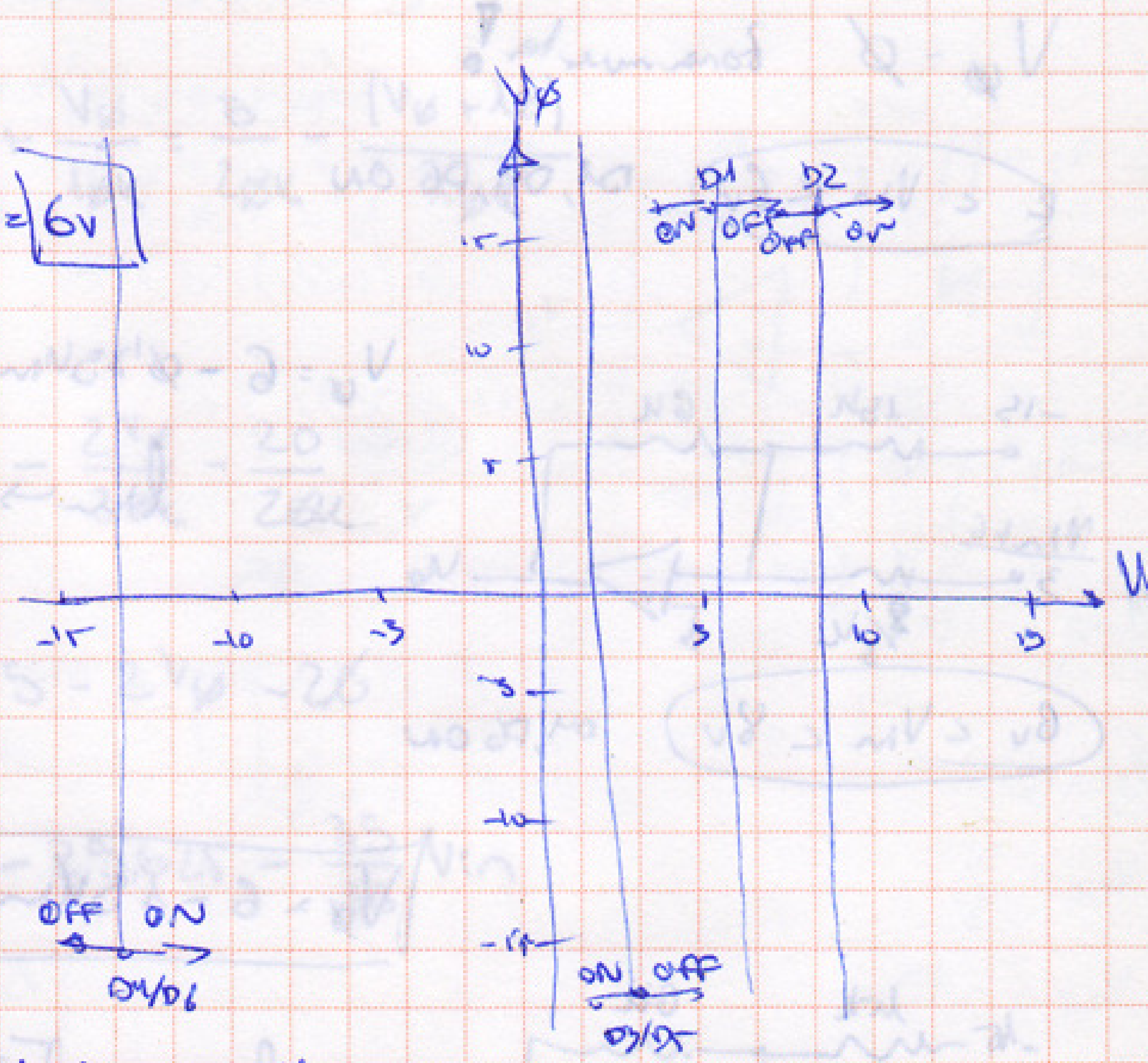
D1 ON D2 OFF

Punto crítico D1

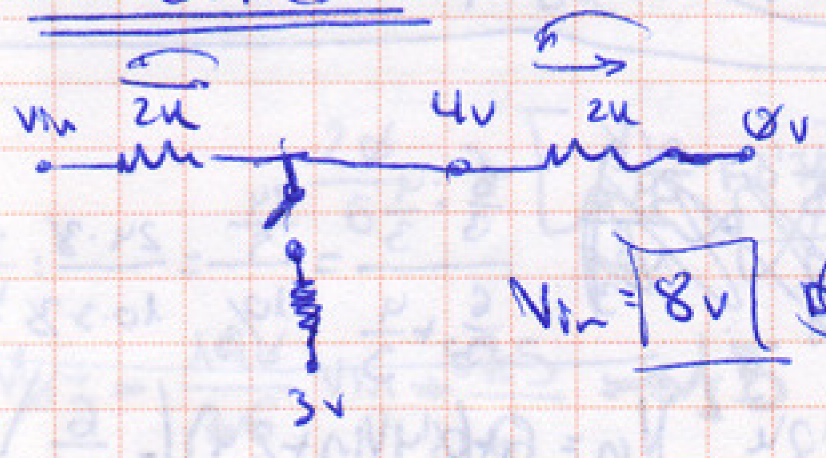


$V_{in} = 3 + \frac{3V}{2k} \cdot 2k = \boxed{6V}$

D2 OFF

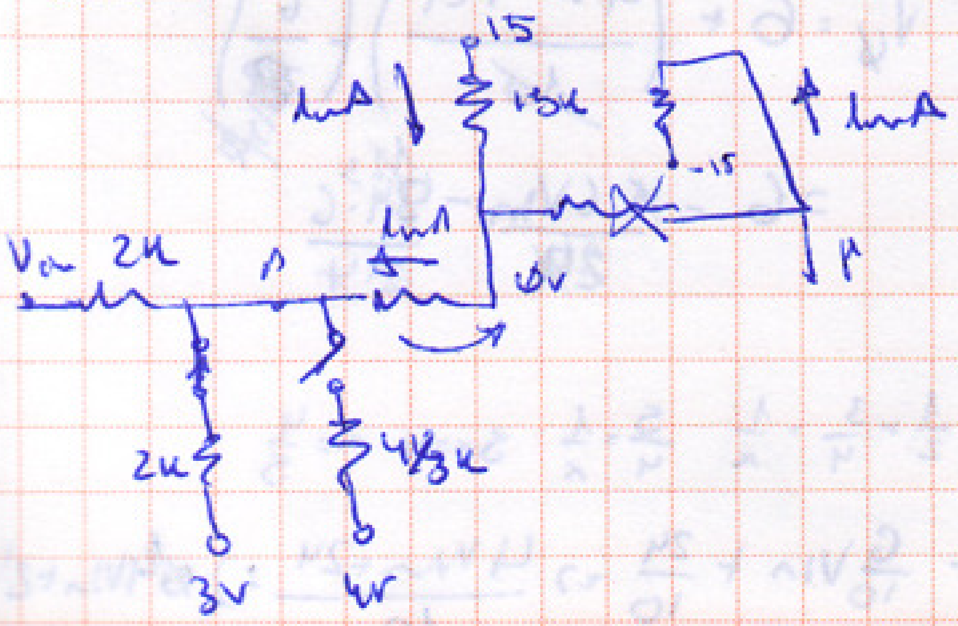


Punto crítico D2



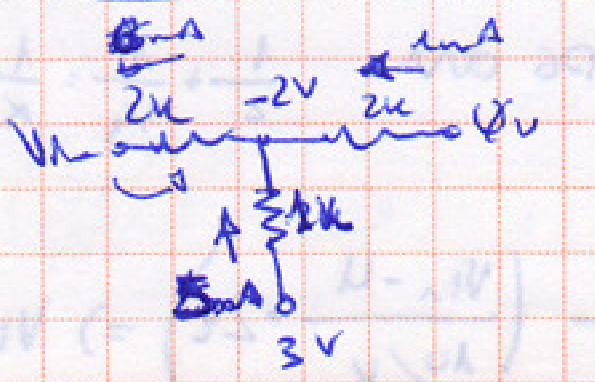
$V_{in} = \boxed{8V}$ D1 OFF

Punto crítico D4/D6



$V_A = -1mA \cdot 2k = -2V$

D2 OFF D1 ON



$V_{in} = -2 - 6mA \cdot 2k = \boxed{-14V}$

$-15 < V_{in} < -14$ D1, D3, D5 ON

$$V_\varnothing = 15\cdot\left(-\frac{6k}{15k}\right) + \left(V_{in} - \frac{V_{in}-3}{3k}2k\right)\cdot\left(-\frac{6k}{2+\frac{2}{3}k}\right)$$

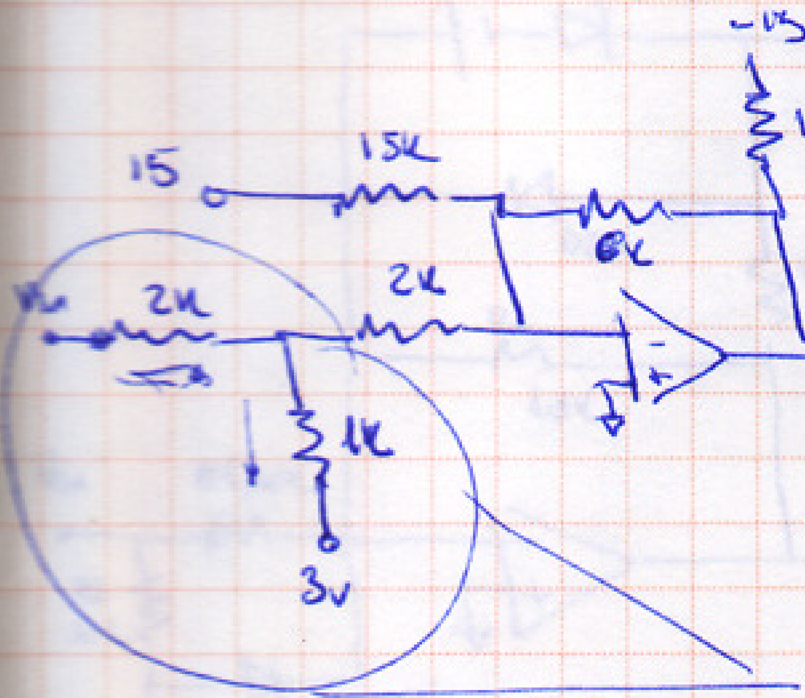
$$= -6 - 2'25\,V_{in} - 2'25\,\frac{V_{in}-3}{3k}2k$$

$$= -6 - 2'25\,V_{in} - 1'5\,V_{in} + 4'5$$

$$= -1'5\,V_{in} - 3'25$$

$$\frac{6}{3}+\frac{2}{3} = \frac{8}{3}$$

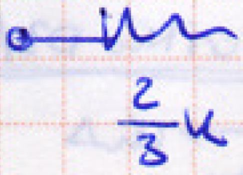
$$\frac{6k}{\frac{8}{3}k} = \frac{18k}{8k} = 2'25$$



$$V_\varnothing = 15\cdot\left(-\frac{6k}{15k}\right) + \left(\frac{V_{in}+6}{3}\right)\left(-\frac{6k}{8/3\,k}\right)$$

$$V_\varnothing = -6 - \frac{2'25}{3}V_{in} - 4'5\varnothing = \boxed{-\varnothing'75V_{in} - 1\varnothing'5}$$

$I_{in} \to [\varnothing'75, \varnothing]$ ok!



$$-\left(\frac{V_{in}-3}{3k}\cdot 2k\right)$$

$$V_{in} - \frac{2V_{in}-6}{3} \to \frac{3V_{in}-2V_{in}+6}{3} \to \frac{V_{in}+6}{3}$$

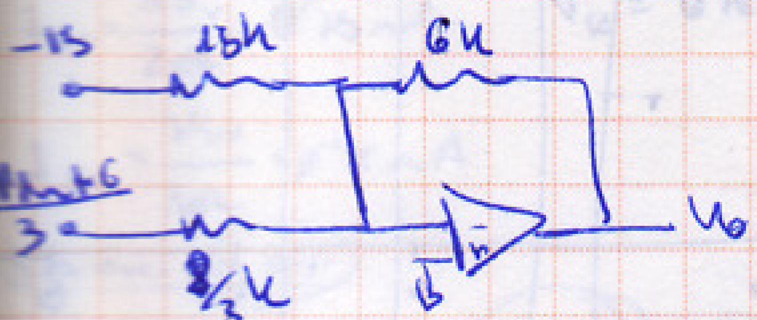
$-14 < V_{in} < 2$ D1, D3, D4, D5, D6 ON

$V_\varnothing = \varnothing$ forzosamente!

$2 < V_{in} < 6v$ D1, D4, D6 ON

$$V_\varnothing = 6 - \varnothing'75V_{in} - 4'5\varnothing = \boxed{-\varnothing'75V_{in} + 1'5\varnothing}$$

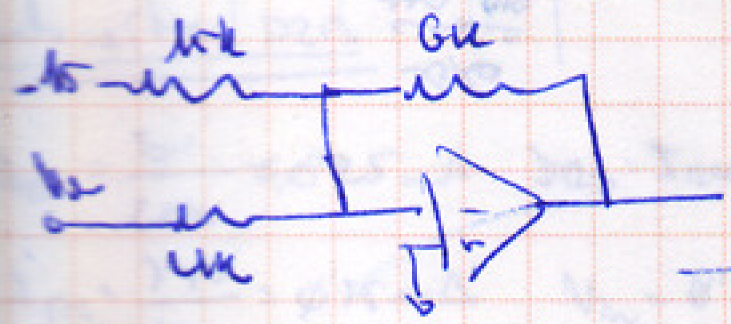
$I_{in} \to [\varnothing, -3]$ ok!



$6v < V_{in} < 8v$ D4, D6 ON

$$\boxed{V_\varnothing = 6 - 1'5V_{in}}$$

$I_{in} \to [-3, -6]$



$$\frac{\frac{6}{3}\cdot\frac{4}{3}}{\frac{6}{3}+\frac{4}{3}} = \frac{\frac{24}{9}}{10/3} = \frac{24\cdot 3}{10\cdot 3\cdot 3} = \frac{8}{10} = \varnothing'8k$$

$2'8k$

$$\boxed{V_\varnothing = 6 + (\varnothing'4V_{in} + 2'4)\left(-\frac{6}{2'8}\right)}$$

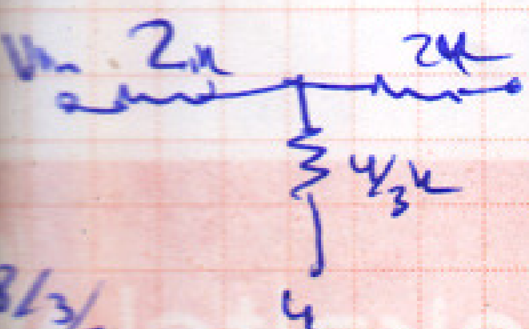
$$V_\varnothing = 6 + \left(\frac{4V_{in}+24}{10}\right)\left(-\frac{6}{28}\right)$$

$$= 6 - \frac{4\cdot 6V_{in}}{28} - \frac{24\cdot 6}{2'4}$$

$8v < V_{in} < 15v$ D2, D4, D6 ON

$$\frac{1}{2}+\frac{1}{4/3} = \frac{1}{x}$$

$$\frac{1}{2}+\frac{3}{4} = \frac{1}{x} \quad \frac{5}{4} = \frac{1}{x} \quad 5x = 4 \quad x = \frac{4}{5}$$



$$V_{in} - \left(\frac{V_{in}-4}{10/3k}\cdot 2k\right) \Rightarrow V_{in} - \frac{6}{10}V_{in} + \frac{24}{10} \Rightarrow \frac{4V_{in}+24}{10} \Rightarrow \varnothing'4V_{in} + 2'4$$

$$\frac{8/3}{10/3}$$

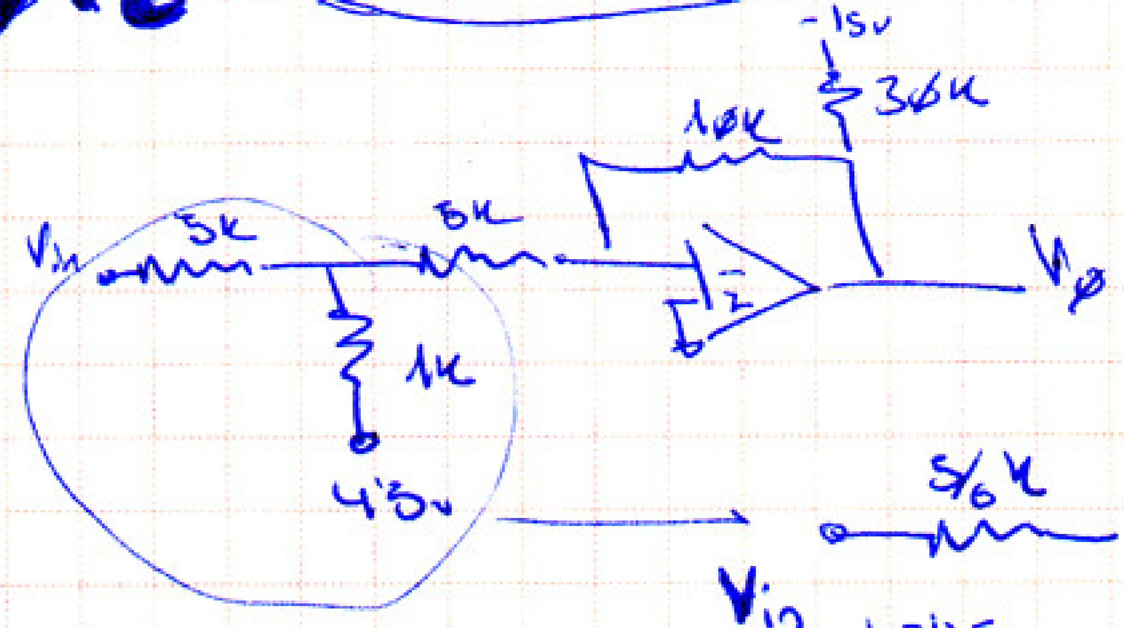
$$V_\varnothing = 6 + \left(\frac{4V_{in}+24}{10}\right)\left(-\frac{6k}{8/10k}\right) = 6 - \frac{24V_{in}}{8} - 24\frac{6}{8} = 6 - 3V_{in} - 18$$

$$\frac{6}{\varnothing'8} = 7'5$$

$$V_\varnothing = -3V_{in} - 12$$

★c

$-15 < V_{in} < 3'75$ D2 ON



$$V_\emptyset = (-15)\left(-\frac{10k}{30k}\right) + \left(\frac{V_{in}}{6}+3'75\right)\left(-\frac{10k}{6/7k}\right)$$

$$= 5 - \frac{70}{36}V_{in} - \frac{70}{36}3'75$$

$$= \frac{180-262'5}{36} - \frac{70}{36}V_{in}$$

$$= -\frac{35}{18}V_{in} - \frac{82'5}{36} = -\frac{35}{18}V_{in} - \frac{55}{24}$$

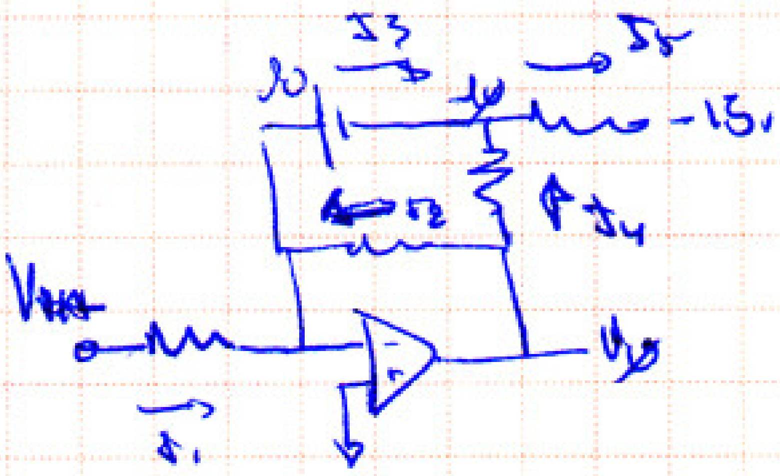
$$\lim \to \left[26'875, -9'58\overline{3}\right]$$

$36 \to 2\cdot3\cdot3\cdot\cancel{2}$

$7 \to 2\cdot\cancel{2}\cdot5$

$\frac{165}{72} \to 5\cdot\cancel{3}\cdot11$, $2\cdot2\cdot2\cdot3\cdot\cancel{3}$

$3'75 < V_{in} < 9$ D3, D2 ON



$$I_1 + I_2 = I_3$$

$$I_3 = I_5 - I_4$$

$$I_1 + I_2 = I_5 - I_4$$

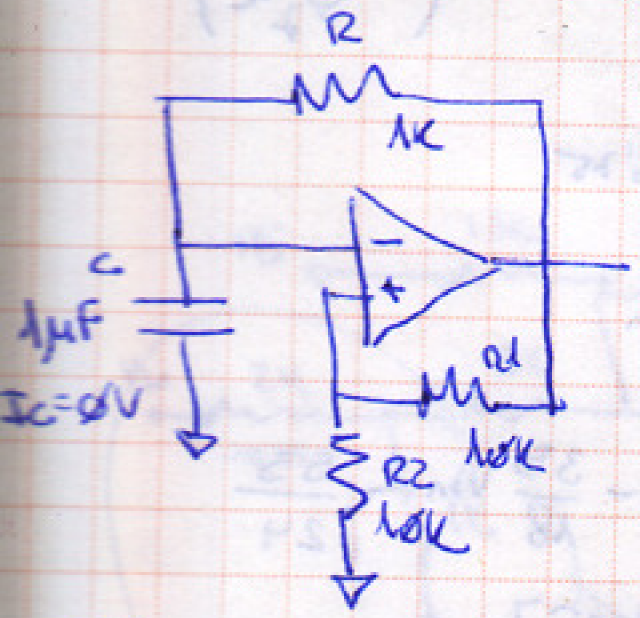
$$\frac{\frac{V_{in}}{6}+3'75}{6/7k} + \frac{V_\emptyset}{10k} = \frac{5}{20k} - \frac{(V_\emptyset + 10)}{10k}$$

$$\frac{7\left[\frac{V_{in}}{6}+3'75\right]}{6k} + \frac{2V_\emptyset}{20k} = \frac{5}{20k} - \frac{2V_\emptyset}{20k} - \frac{20}{20k}$$

$$\frac{20}{6}\cdot7\left[\frac{V_{in}}{6}+3'75\right] + 2V_\emptyset = 5 - 2V_\emptyset - 20$$

$$4V_\emptyset = -\frac{140}{36}V_{in} - \frac{525}{6} - 15 \Rightarrow V_\emptyset = -25'625 - \frac{35}{36}V_{in}$$

EA - Aestable ✓



Suponemos $V_\emptyset = +15v$ al principio

$t_\emptyset$

$V_{CI} = \emptyset$

$V_{CF} = 15v$

$\tau_\emptyset = 1k \cdot 1\mu F = 1ms$

$V^+ = 7'5v$

$V_C(t) = V_{CF} + (V_{CI} - V_{CF})\, e^{-t/\tau_\emptyset}$

$7'5 = 15 + (\emptyset - 15)\, e^{-t/\tau_\emptyset}$

$\frac{-7'5}{-15} = e^{-t/\tau_\emptyset}$ $\quad \boxed{\Delta t_\emptyset = 1ms \cdot \ln 2}$

$\emptyset'693 ms$

t_1

$V_{CI} = 7'5v$

$V_{CF} = -15v$

$\tau_1 = \tau_\emptyset = 1ms$

$V^+ = -7'5v$

$V_C(t) = V_{CF} + (V_{CI} - V_{CF})\, e^{-t/\tau_1}$

$-7'5 = -15 + [7'5 - (-15)]\, e^{-\Delta t_1/\tau_1}$

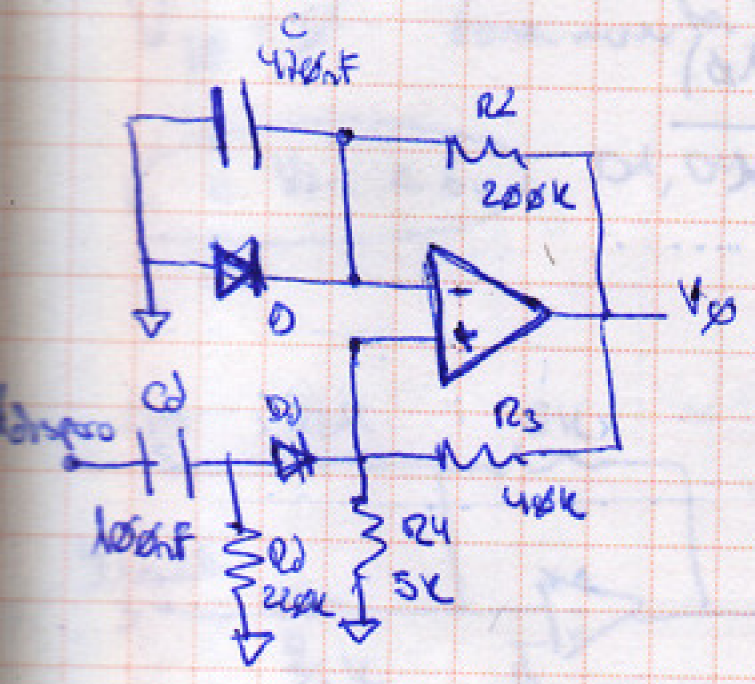
$\frac{7'5}{22'5} = e^{-\Delta t_1/\tau_1}$ $\quad \boxed{\Delta t_1 = 1ms \cdot \ln 3}$

$1'\emptyset 986\, ms$

EA - Monoestable ✓

¿Cuál es el estado estable?

Suponemos $V_{0I} = +15v$



$V^+ = 15v \cdot \frac{5k}{45k} = \frac{5}{3}v$

C se va cargando. Cuando V_C sea $\frac{5}{3}V^+$ $V_\emptyset$ cambiará de estado a $-15v$. Luego, este no es el estado estable.

Δt_{mono}

$V_{CI} = \emptyset$

$V_{CF} = 15$

$\tau_{mon} = 200k\Omega \cdot 470nF = 94ms$

$V^+ = \frac{5}{3}v$

$V_C(t) = V_{CF} + (V_{CI} - V_{CF})\, e^{-\Delta t_{mono}/\tau_{mono}}$

$\frac{5}{3} = 15 + (\emptyset - 15)\, e^{-\Delta t_{mono}/\tau_{mon}}$

$\frac{-40/3}{-45/3} = e^{-\Delta t_{mono}/\tau_{mono}}$

$\frac{9}{8} = e^{\Delta t_{mono}/\tau_{mono}}$

$\boxed{\Delta t_{mono} = 94ms \cdot \ln(9/8) = 11'07ms}$

Δt_{re}

$V_{CI} = \frac{5}{3}$

$V_{CF} = -15v$

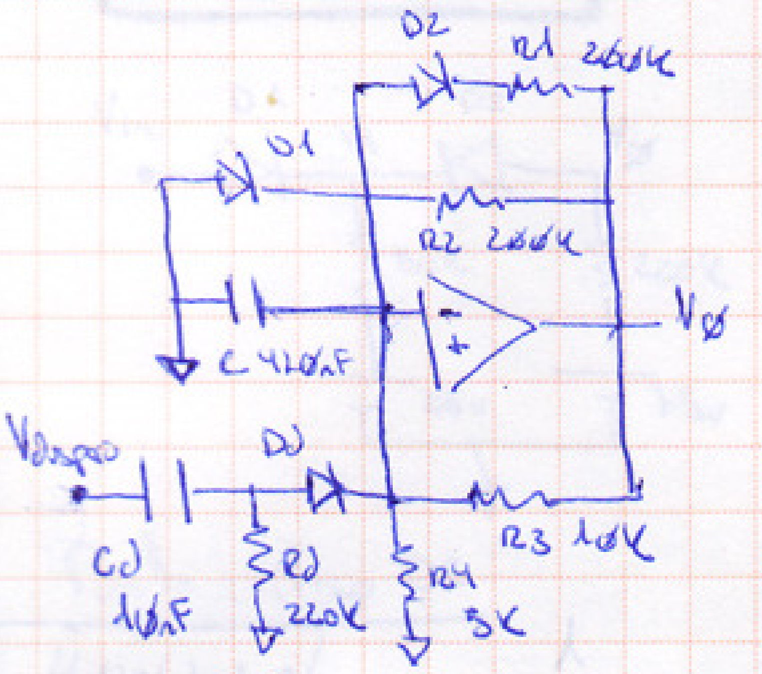
$\tau_{re} = 470nF \cdot 200k = 94ms$

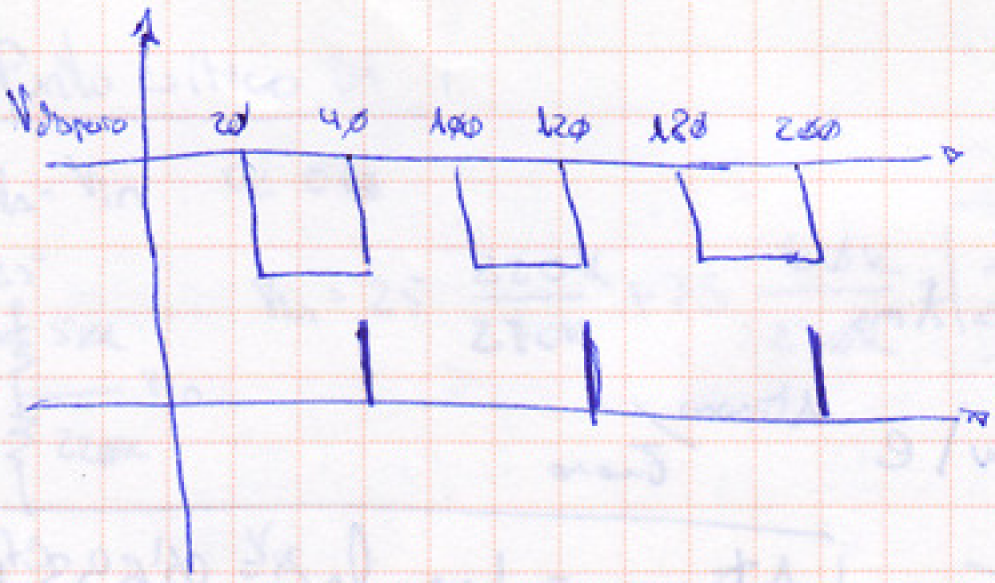
$V_C(t) = V_{CF} + (V_{CI} - V_{CF})\, e^{-\Delta t_{re}/\tau_{re}}$

$\emptyset = -15v + \left(\frac{5}{3} - (-15)\right) e^{-\Delta t_{re}/\tau_{re}}$

$\frac{15}{50/3} = \frac{45}{50} = \frac{9}{10} = e^{-\Delta t_{re}/\tau_{re}}$ $\quad \boxed{\Delta t_{re} = 94ms \cdot \ln\left(\frac{10}{9}\right) = 9'9ms}$

EA - Monoestable ✓





Suponemos $V_\emptyset = +15$ estable

$V^+ = 15 \frac{5K}{15K} = 5v$

D2 OFF D1 OFF

C se cargará a través de R2. Cuando $V_c = 5v$, $V_\emptyset$ cambia a -15

Este NO es el estado estable

Suponemos $V_\emptyset = -15$ estable

D2 ON D1 ON

C no se cargará nunca

Este es el estado ESTABLE

Δt_{mono}

$V_{CI} = \emptyset$

$V_{CF} = 15v$

$\tau_{mono} = 470nF \cdot 200K = 94ms$

$V^+ = 5v$

$5v = 15v + (\emptyset - 15v)\, e^{-\Delta t_{mono}/\tau_{mono}}$

$\frac{-10}{-15} = \frac{2}{3} \Rightarrow \boxed{\Delta t_{mono} = 94ms \ln\left(\frac{3}{2}\right) = 38'11ms}$

Δt_{re}

$V_{CI} = 5v$

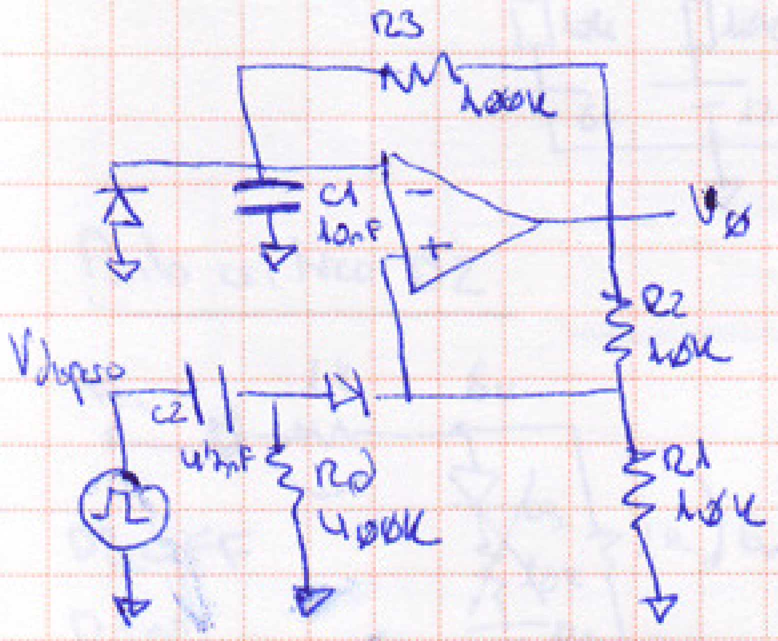
$V_{CF} = -15v$

$\tau_{re} = 100K \cdot 470n = 47ms$

$\emptyset = -15\, [5 - (-15)]\, e^{-\Delta t_{re}/\tau_{re}}$

$\frac{15}{20} = \frac{3}{4} \Rightarrow \boxed{\Delta t_{re} = 47ms \ln\left(\frac{4}{3}\right) = 13'52ms}$

EA - Monoestable ✓



V1 = ∅V

V2 = 20V

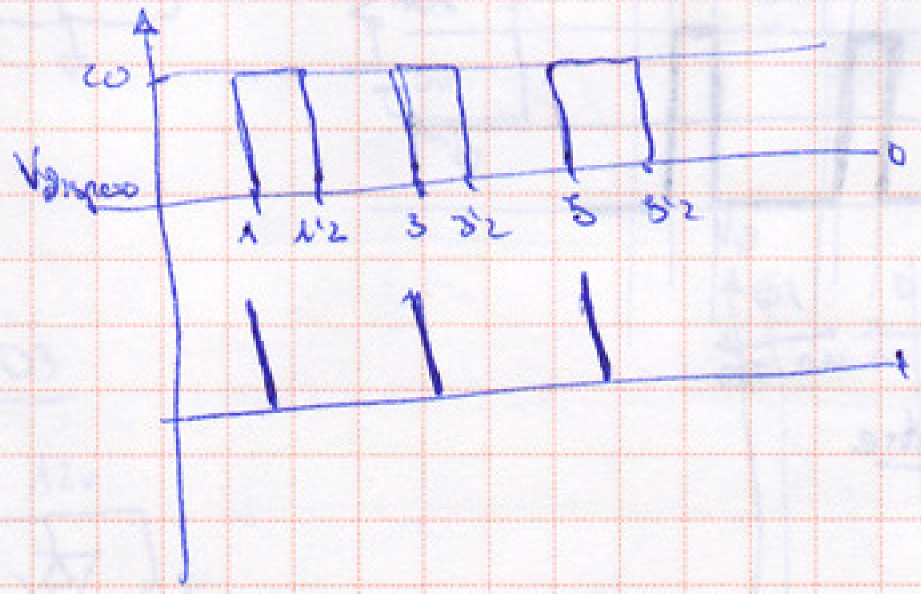
TD = 1ms

TR = 1us

TF = 1us

PW = ∅'2ms

PER = 2ms



Suponemos $V_\emptyset = 15$ estable

$V^+ = 7'5v$

~~[illegible]~~

D1 OFF C se cargará a través de R3. Cuando $V_c = 7'5v^+$, $V_\emptyset$ cambia a $-15v$

Este NO es el estado estable

Suponemos $V_\emptyset = -15$ estable

$V^+ = -7'5v$

D1 ON

C no se cargará nunca. $V_c = \emptyset v$

Δt_{mono}

$V_{CI} = 0V$

$V_{CF} = 15v$

$\tau_{mono} = 10nF \cdot 100k\Omega = 1ms$

$7'5_v = 15_v + (0 - 15v)\, e^{-\Delta t_{mono}/\tau_{mono}}$

$\frac{1}{2} = e^{-\frac{\Delta t_{mono}}{\tau_{mono}}}$ $\boxed{\Delta t_{mono} = 1ms \cdot \ln 2 = 0'693\, ms}$

Δt_{re}

$V_{CI} = 7'5v$

$V_{CF} = -15v$

$\tau_{mono} = 10nF \cdot 100k\Omega = 1ms$

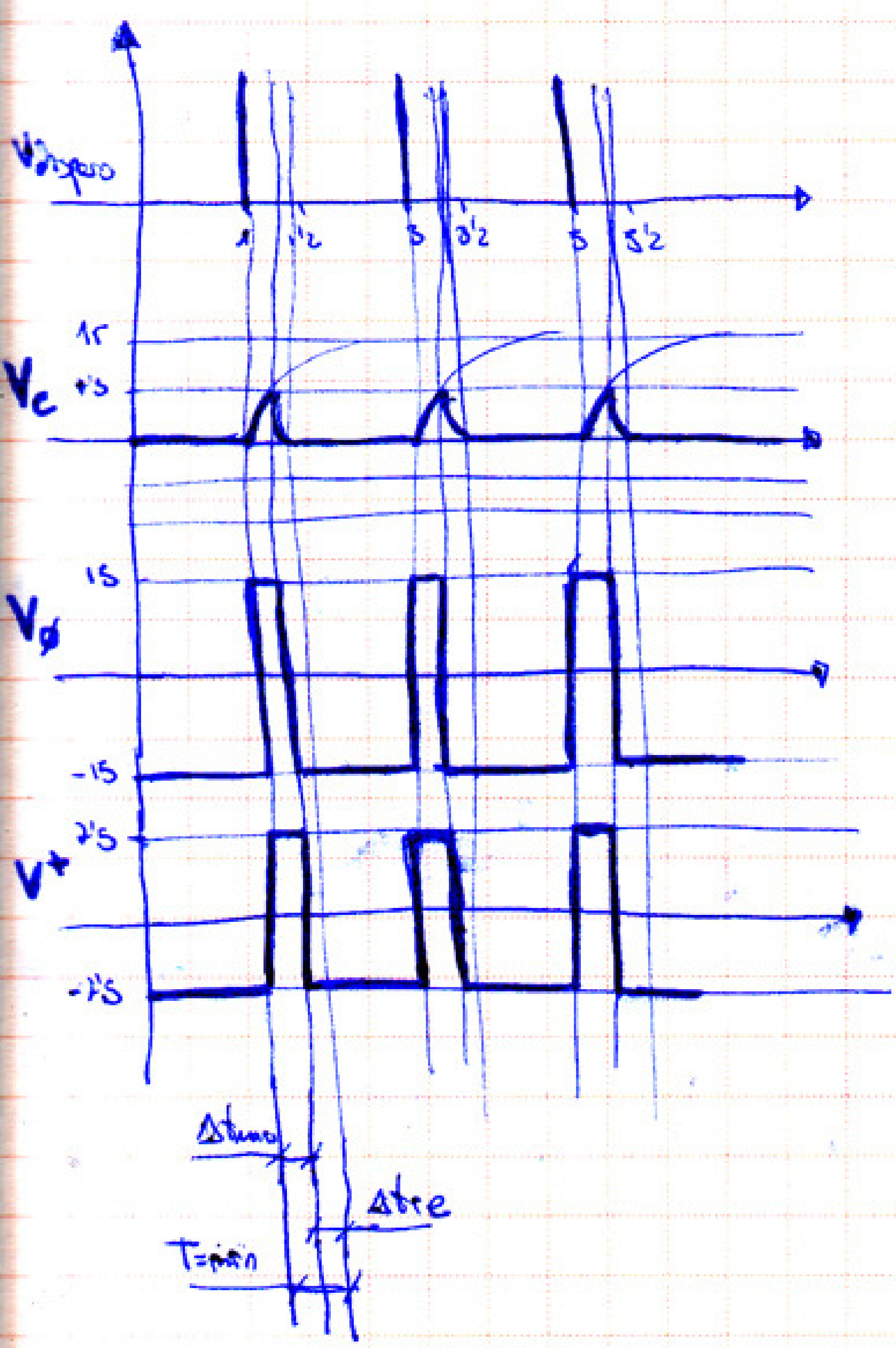
$0 = -15 + [7'5 - (-15)]\, e^{-\Delta t_{re}/\tau_{re}}$

$\frac{15}{22'5} = \frac{2}{3} \Rightarrow \boxed{\Delta t_{re} = 1ms\, \ln\left(\frac{3}{2}\right) = 0'405\, ms}$

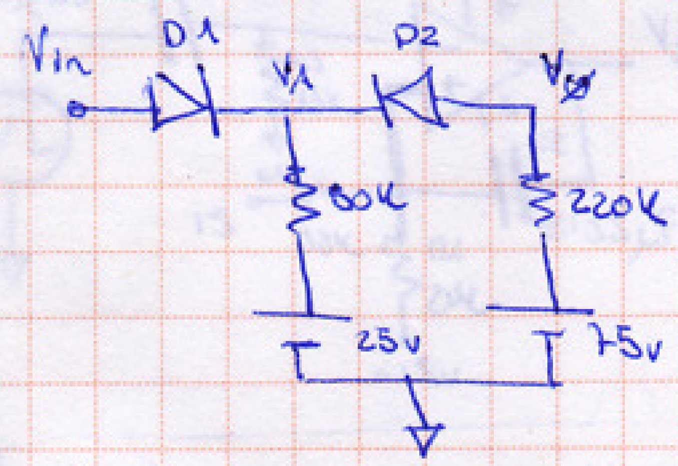
$F_{rex} = \frac{1}{\Delta t_{mono} + \Delta t_{re}} = \frac{1}{1ms\left(\ln 2 + \ln \frac{3}{2}\right)} = \boxed{910'24\, Hz}$

¿En Δt_{re} tiene que llegar a $V_C = 0$ o a $V_C = -7'5v$?

$\Delta V_C = 0$, porque en ese momento empieza a conducir el diodo y el condensador se queda sin cargar.

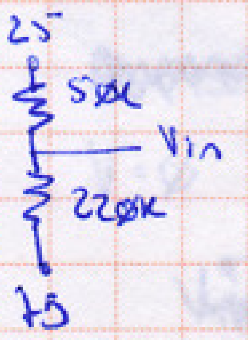


EA - Froga ✓

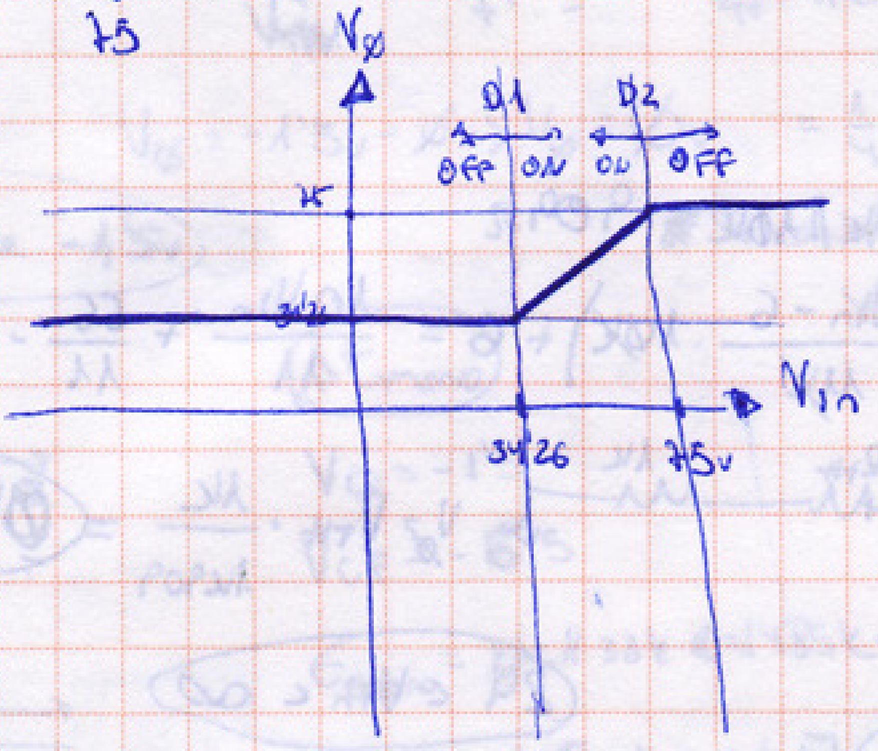


Punto crítico D1

$V_A = V_{in}$ D2 ON



$V_{in} = 25 \frac{220k}{270k} + 75 \frac{50k}{270k} = \boxed{34'26\,v}$



Punto crítico D2

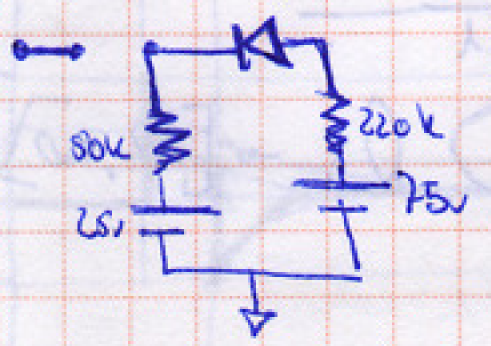
$V_A = 75\,v$ D1 ON

$V_{in} = 75\,v$

D1 OFF

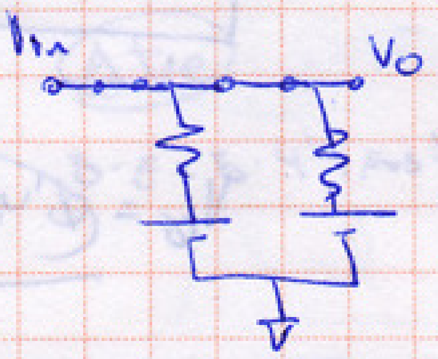
No puede haber dos voltajes diferentes en el mismo punto

$-\infty < V_{in} < 34'26v$



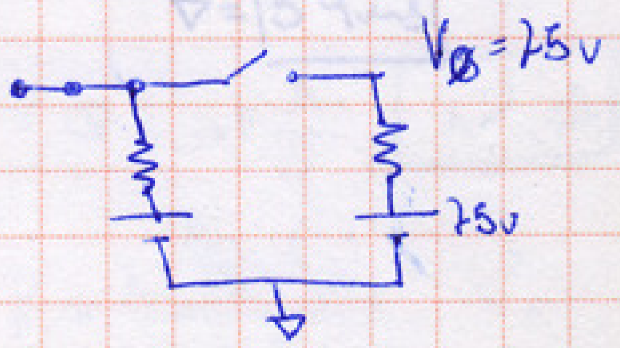
$\boxed{V_ø = 34'26v}$

$34'26v < V_{in} < 75v$

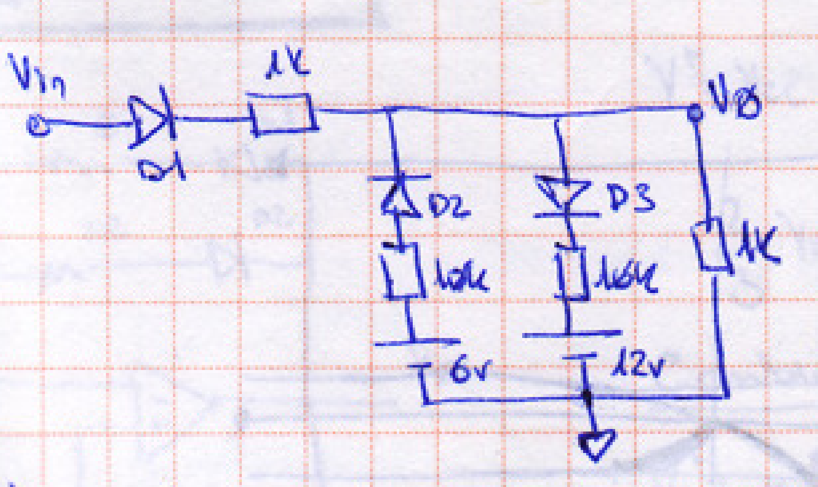


$V_ø = V_{in}$

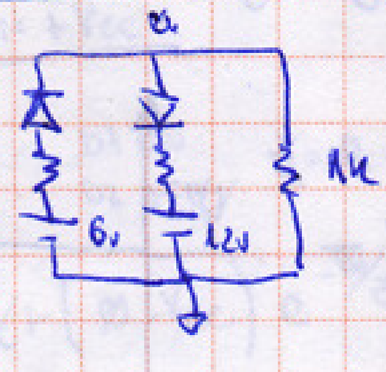
$75 < V_{in} < \infty$



EA - Froga ✓

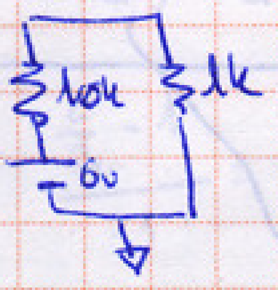


Punto crítico D1

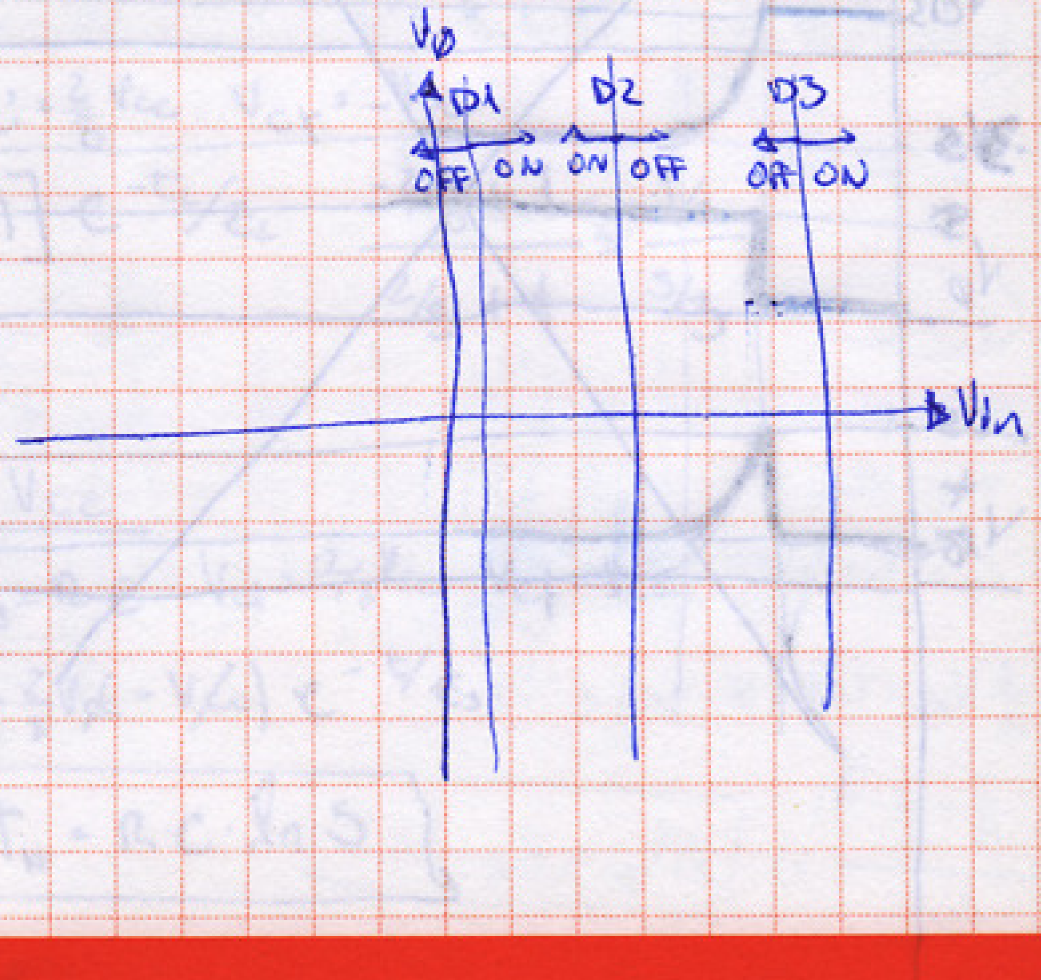


D3 OFF

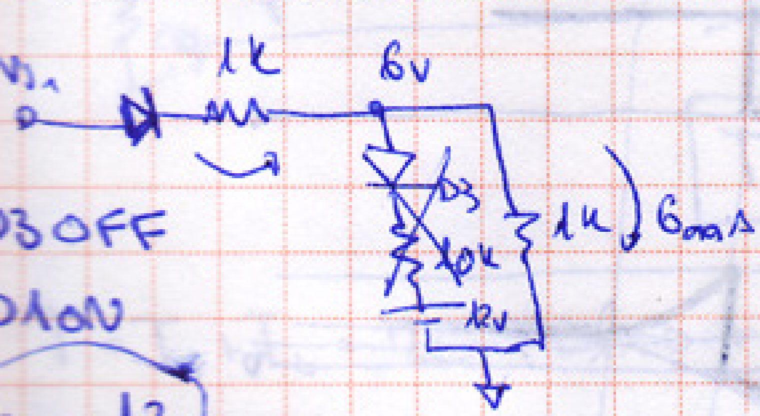
D2 ON



$V_{in} = \frac{6v}{11k} \cdot 1k = 0'54\,v$



Punto crítico D2

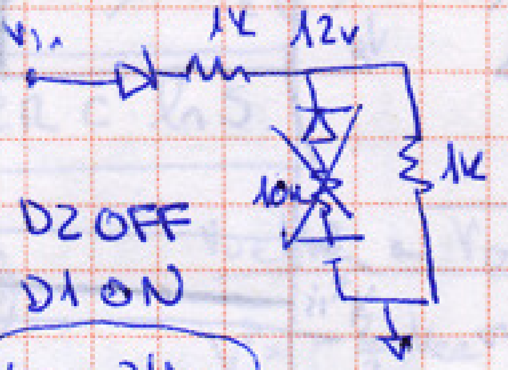


D3 OFF

D1 ON

$V_{in} = 12v$

Punto crítico D3

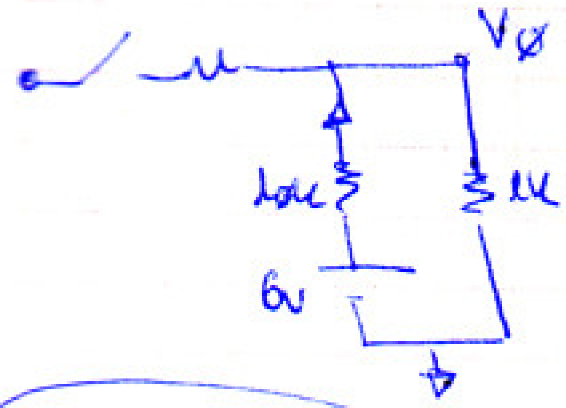


D2 OFF

D1 ON

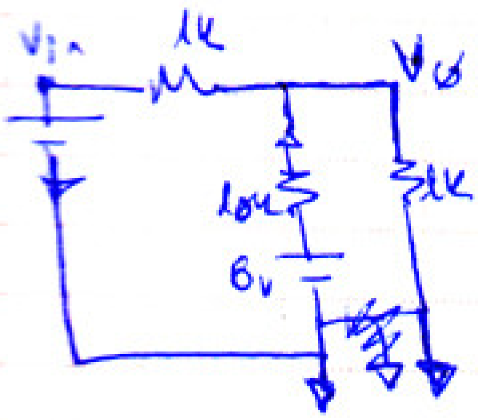
$V_{in} = 24v$

$-\infty < V_{in} < 0'54$



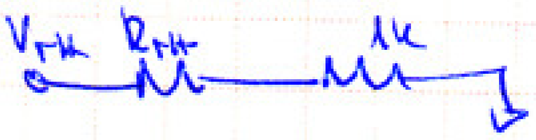
$$V_\emptyset = \frac{6v}{11k}\cdot 1k = 0'54\,v$$

$0'54 < V_{in} < 12$



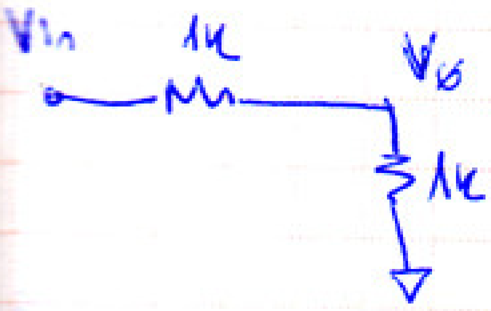
$$R_{TH} = 1k \,//\, 10k = 909\,\Omega$$

$$V_{TH} = \left(\frac{V_{in}-6}{11k}\cdot 10k\right) + 6 = \frac{10V_{in}}{11} + \frac{66}{11} - \frac{60}{11} = \frac{10V_{in}+6}{11} \quad l_{in} \to [0'54, 6v]$$



$$V_\emptyset = V_{TH}\cdot\frac{1k}{1k909} = 0'476\,V_{in} + 0'286$$

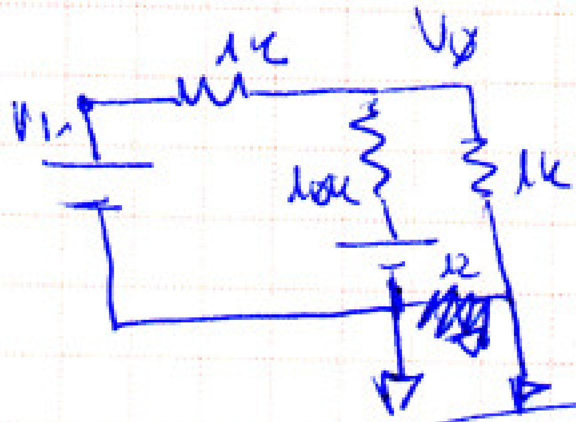
$12 < V_{in} < 24$



$$V_\emptyset = V_{in}/2$$

$$l_{in} \to [6, 12]$$

$24 < V_{in} < \infty$



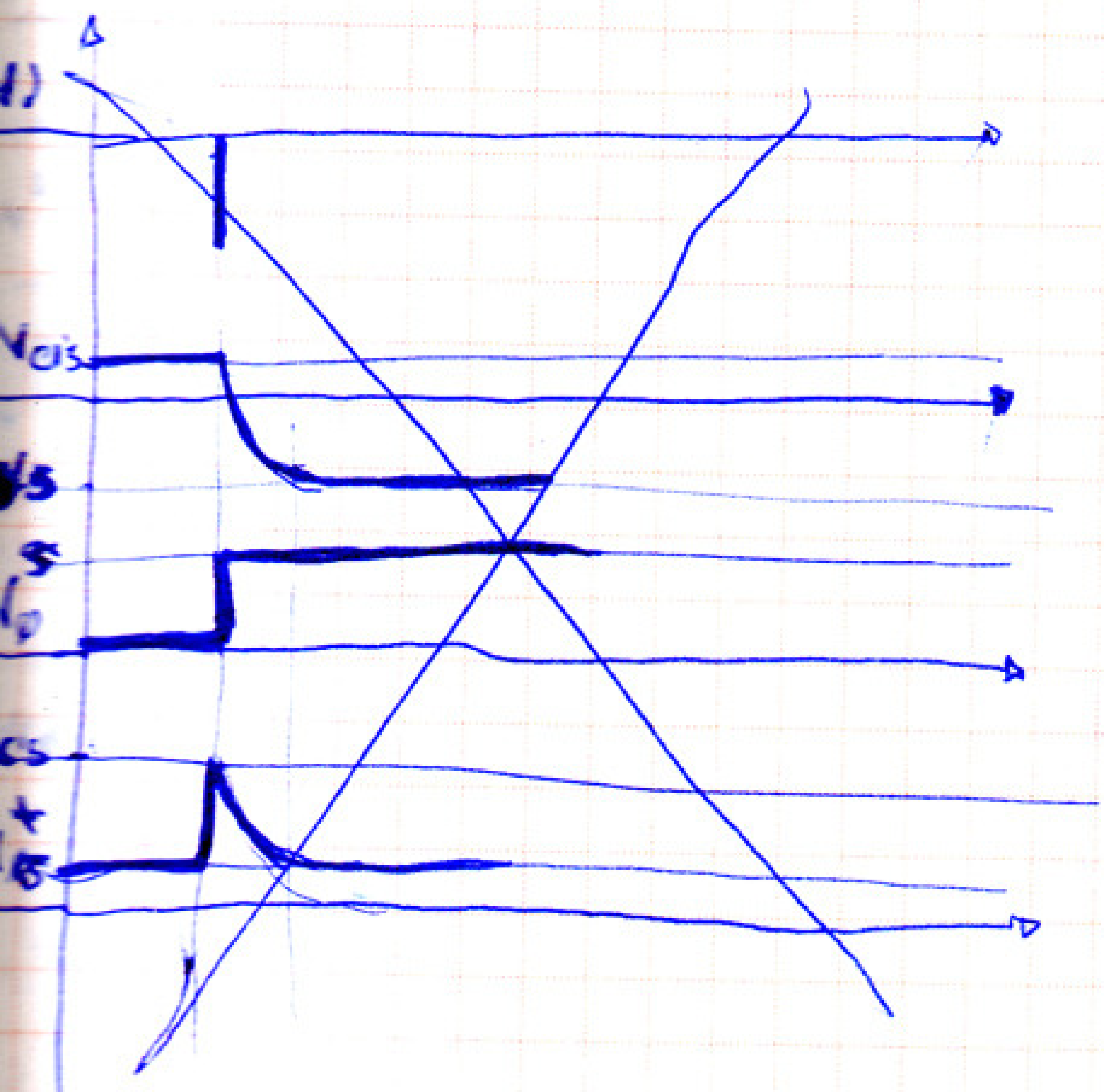
$$R_{TH} = 909\,\Omega$$

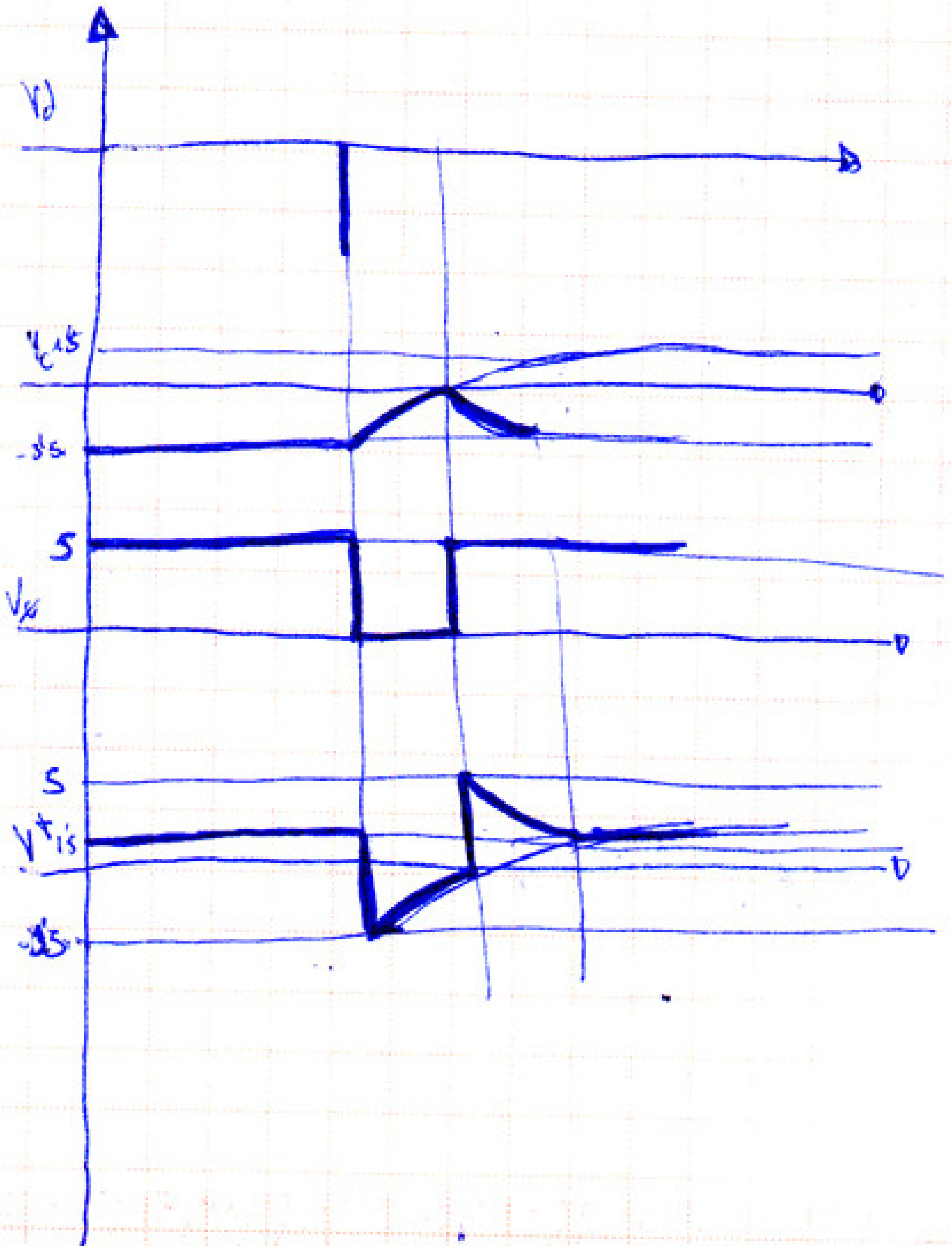
$$V_{TH} = \left(\frac{V_{in}-12}{11k}\cdot 10k\right) + 12 = \frac{10V_{in}+12}{11}$$

$$V_\emptyset = 0'476\,V_{in} + 0'5714 \quad l_{in} \to [12, \infty]$$

EA - Froga

El monoestable de la página siguiente, con los valores de las resistencias cambiados.

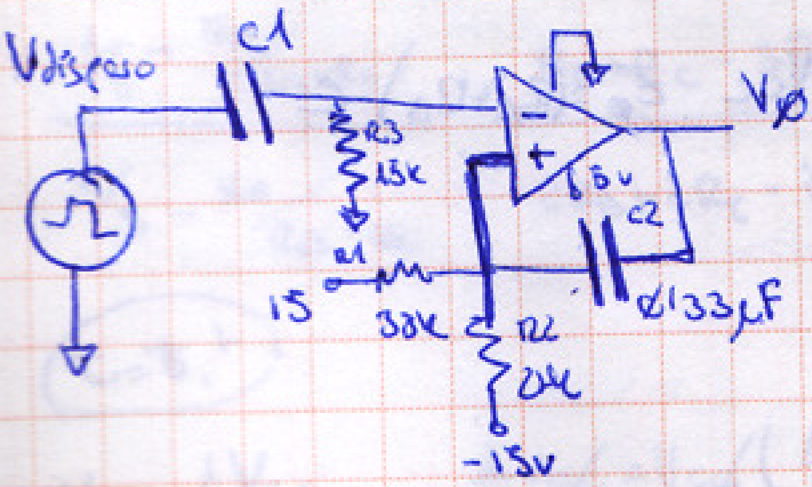


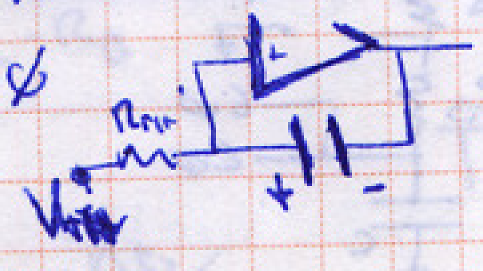


EA - Monoestable ✓

→ $V_\emptyset$, V^+, V_c

→ Polaridad y amplitud aproximada de Vdisparo.





$V^+ = \emptyset$

$\cancel{V^+ = 15v}$ $-1'5v$

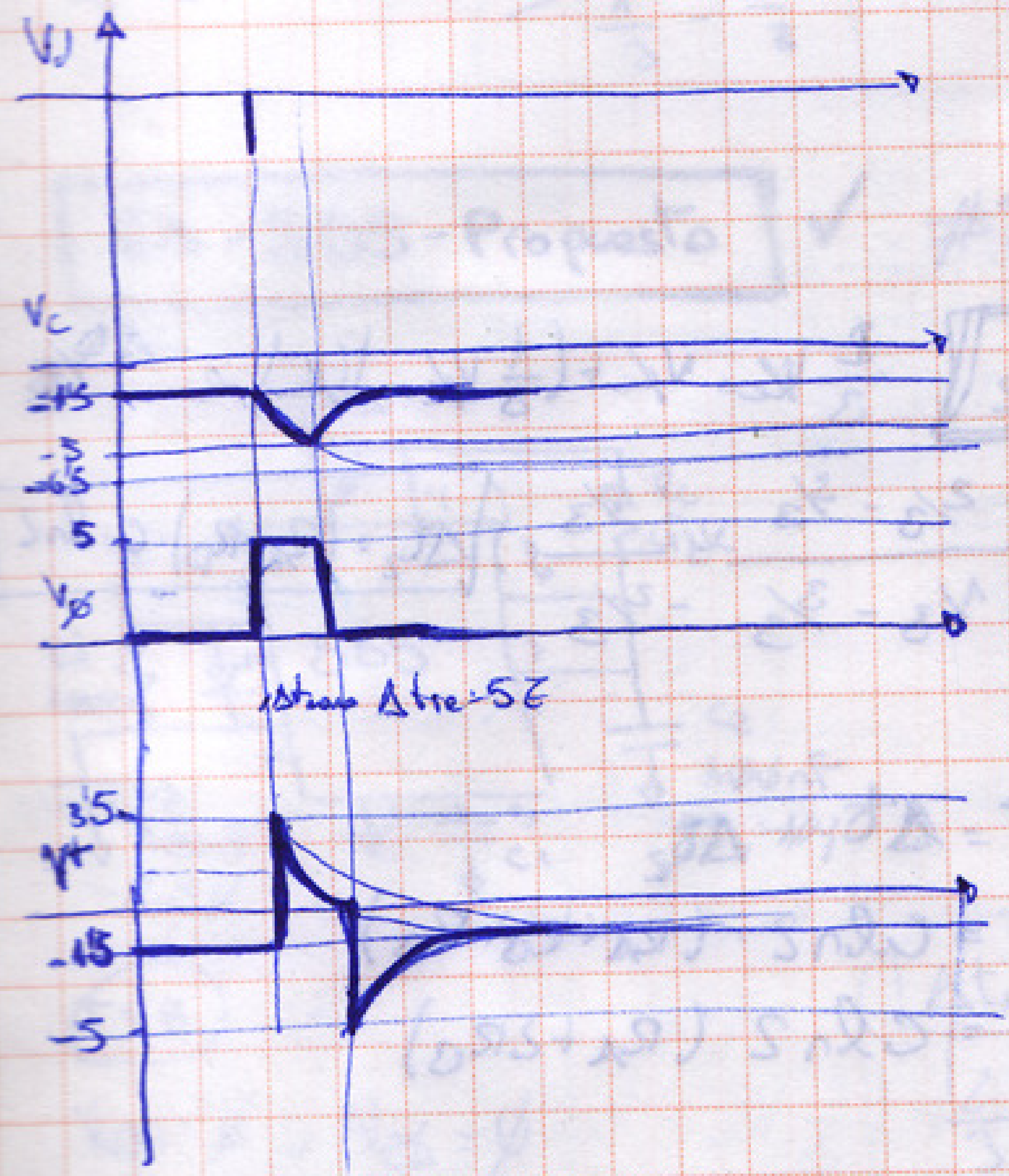
$V_{th} = 15\,\frac{27}{60} - 15\,\frac{33}{60} = \frac{15}{60}(27-33)$

$V_\emptyset = -1'5v - \emptyset \Rightarrow V_\emptyset = \emptyset v$ $\quad = \frac{1}{4}\cdot -6 = -1'5v$

* Si cambiamos los valores de las Rs

$V^+ = 1'5v$ Disparo más negativo que $1'5v$.

Vdisparo tiene que ser más negativo que -1'5v



Δtmono

$V_{ci} = -1'5$

$V_{cF} = -6'5$

$\tau_{mono} = 24k \parallel 33k \cdot C = 14'85k \cdot \emptyset'33\mu F = 4'9\,ms$

$V_c(t) = -6'5\left[-1'5 - (-6'5)\right] e^{-\Delta t_{mono}/\tau_{mono}}$

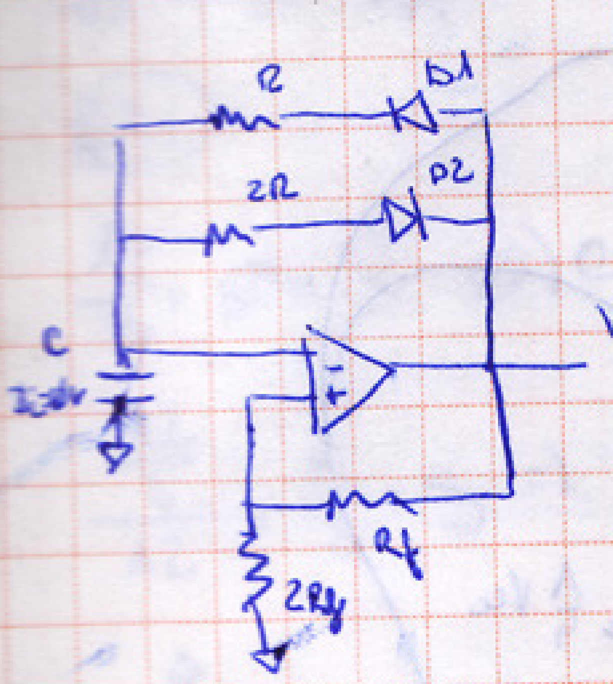
$\frac{-5+6'5}{5} = e^{-\Delta t_{mono}/\tau_{mono}}$ $\quad \Delta t_{mono} = 4'9\,ms\, \ln\frac{10}{3}$

$= \boxed{5'9\,ms}$

Δtre

$5\cdot\tau = 5\cdot 4'9\,ms = \boxed{24'5\,ms}$

EA - Aestable ✓



Suponemos $V_{si} = +V_{cc}$

$V^+ = V_{cc}\,\frac{2R_f}{3R_f}$ D1 ON D2 OFF $\tau_1 = R\cdot C$ $V_{ci} = \emptyset$ $V_{cf} = V_{cc}$

$\frac{2}{3}\cancel{V_{cc}} = \cancel{V_{cc}} + (\emptyset - \cancel{V_{cc}})\, e^{-T_H/\tau}$ $\quad \frac{\frac{2}{3}-1}{-1} = e^{-T_H/\tau_1}$ $\quad \boxed{T_\emptyset = R\cdot C\cdot \ln 3}$

Cambio a $V_\emptyset = -V_{cc}$

$V^+ = -\frac{2}{3}V_{cc}$ $\quad \tau_2 = 2\cdot R\cdot C$ $\quad V_{ci} = \frac{2}{3}V_{cc}$ $\quad V_{cf} = -V_{cc}$

$-\frac{2}{3}\cancel{V_{cc}} = -\cancel{V_{cc}}\left[\frac{2}{3}\cancel{V_{cc}} - (-\cancel{V_{cc}})\right] e^{-T_L/\tau_2}$ $\quad \frac{-2/3+1}{2/3+1} = \frac{1/3}{5/3}$

$\boxed{T_L = 2R\cdot C\cdot \ln 5}$

Vuelta a $V_\emptyset = V_{cc}$

$V^+ = -\frac{2}{3}V_{cc}$ $\quad \tau_3 = R\cdot C$ $\quad V_{ci} = -2/3\,V_{cc}$ $\quad V_{cf} = V_{cc}$

$\frac{2}{3}\cancel{V_{cc}} = \cancel{V_{cc}} + \left(-\frac{2}{3}\cancel{V_{cc}} - \cancel{V_{cc}}\right) e^{-t/\tau_3}$

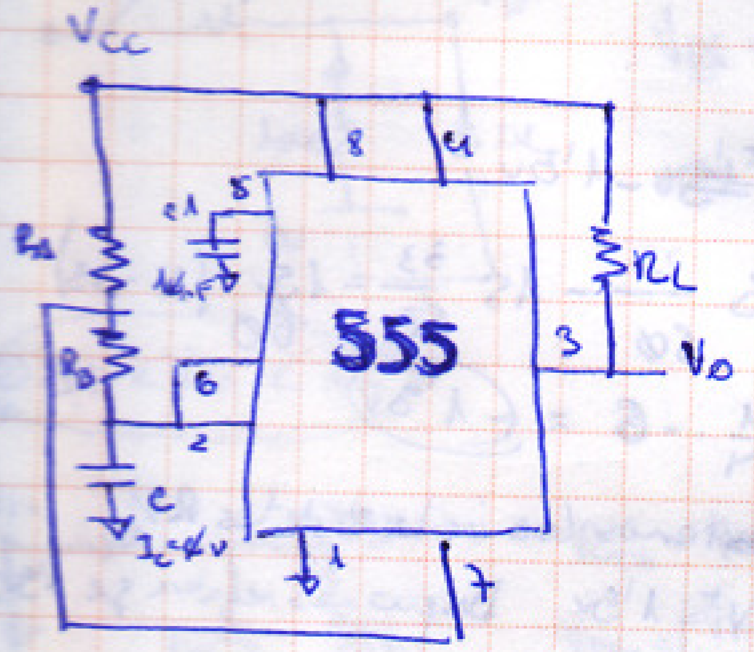
$\frac{-1/3}{-5/3} = \frac{1}{5}$ $\quad \boxed{T_H = R\cdot C\cdot \ln 5}$

$T = T_H + T_L = RC\cdot(2\ln 5 + \ln 5)$

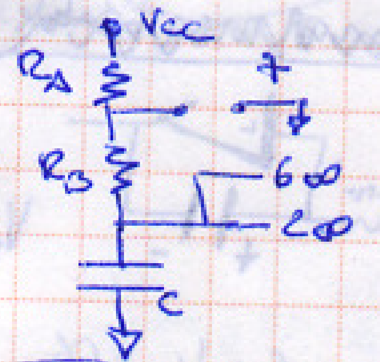
$= 3RC\ln 5$

$\boxed{F = \frac{1}{3RC\ln 5}}$ $\quad \frac{T_L}{T_H} = \frac{2\cancel{RC}\cancel{\ln 5}}{\cancel{RC}\cancel{\ln 5}} = 2$

EA - 555 (Astable bipolar básico) ✓ #1



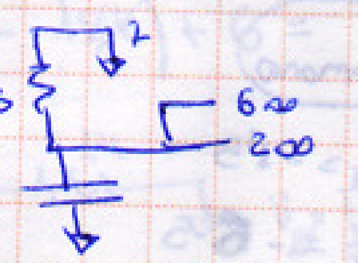
$t = 0^+$



$V_{ci} = 0 \quad V_{cf} = V_{cc} \quad \tau_0 = (R_A + R_B) \cdot C$

$t = t_0^+$

$V_{ci} = \frac{2}{3} V_{cc} \quad V_{cf} = 0\,v \quad \tau_1 = R_B \cdot C$



$t = t_1^+$

$V_{ci} = \frac{1}{3} V_{cc} \quad V_{cf} = V_{cc} \quad \tau_2 = \tau_0$

$\boxed{\Delta t_0}$ $\frac{2}{3} \cancel{V_{cc}} = \cancel{V_{cc}} + (0 - \cancel{V_{cc}}) e^{-\Delta t_0 / \tau_0}$

$\frac{-1/3}{-3/3} \Rightarrow \boxed{\Delta t_0 = (R_A + R_B) \cdot C \cdot \ln 3}$

$\boxed{\Delta t_1}$ $\frac{1}{3} \cancel{V_{cc}} = 0 + (\frac{2}{3} \cancel{V_{cc}} - 0) e^{-\Delta t_1 / \tau_1}$

$\frac{1/3}{2/3} \Rightarrow \boxed{\Delta t_1 = R_B \cdot C \cdot \ln 2}$

$\boxed{\Delta t_2}$ $\frac{2}{3} V_{cc} = V_{cc} + (\frac{1}{3} V_{cc} - V_{cc}) e^{-\Delta t_2 / \tau_2}$

$\frac{2/3 - 3/3}{1/3 - 3/3} = \frac{-1/3}{-2/3} \Rightarrow \boxed{\Delta t_2 = (R_A + R_B) \cdot C \cdot \ln 2}$

$T = \Delta t_1 + \Delta t_2$
$= C \ln 2 \cdot (R_A + R_B + R_B)$
$= C \ln 2 \, (R_A + 2R_B)$

EA - 555 ✓ #2

a) Fijos R_A, R_B, R_C

¿Relación entre Rs para que funcione?

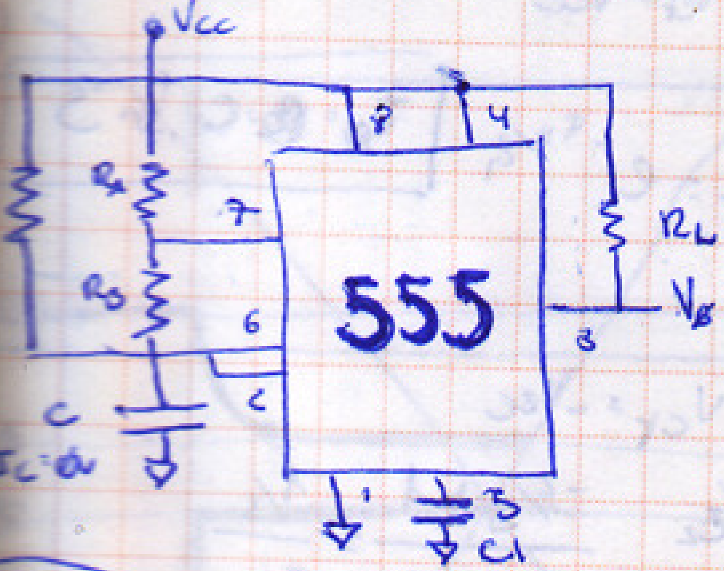
Fórmulas para T y f

b) $R_A = 20k$ $R_C = 30k$ $C = 410nF$ $V_{cc} = 12v$

Calcular y dibujar V_C y V_0 para:

b.a) $R_B = 10k$

b.b) $R_B = 20k$



$t = 0^+$

$V_{ci} = 0v$

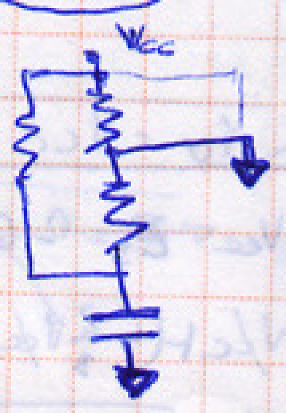
$V_{cf} = V_{cc}$

$\tau = [(R_A + R_B) // R_C] \cdot C$

$\frac{2}{3} V_{cc} = V_{cc} + (0 - V_{cc}) e^{-t/\tau_0}$

$\frac{-\frac{1}{3}}{-\frac{3}{3}} \Rightarrow \boxed{\Delta t_0 = \tau_0 \cdot \ln 3}$

$t = t_0^+$

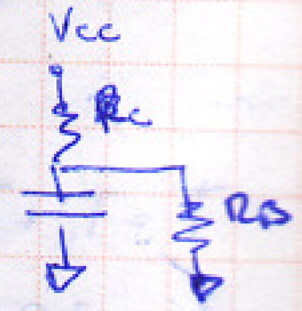


$R_{TH} = R_C // R_B \quad V_{TH} = V_{cc} \frac{R_B}{R_B + R_C} = \frac{1}{4} V_{cc}$

$\tau_1 = (R_C // R_B) C$

~~$\frac{1}{3} V_{cc} = 0 + (\frac{2}{3} V_{cc} - 0) e^{-t/\tau}$~~

~~$\frac{1/3}{2/3} \Rightarrow \Delta t_1 = \tau_1 \ln 2$~~



$\frac{1}{3} \cancel{V_{cc}} > \cancel{V_{cc}} \frac{R_B}{R_B + R_C}$

$\frac{1}{3} R_B + \frac{1}{3} R_C > R_B$

$R_B < \frac{1}{2} R_C$

$\frac{1}{3} \cancel{V_{cc}} = \frac{1}{4} \cancel{V_{cc}} (\frac{2}{3} \cancel{V_{cc}} - \frac{1}{4} \cancel{V_{cc}}) e^{-t/\tau}$

$\frac{\frac{1}{3} - \frac{1}{4}}{\frac{2}{3} - \frac{1}{4}} \Rightarrow \frac{\frac{4-3}{12}}{\frac{8-3}{12}} = \frac{1}{5} \quad \Delta t_1 = \tau_1 \ln 5$

$$\frac{1}{3} = \frac{R_B}{R_B+R_C}\left(\frac{2}{3} - \frac{R_B}{R_B+R_C}\right)e^{-\Delta t_1/\tau_1}$$

$$\boxed{\Delta t_1 = \ln\frac{2R_C - R_B}{R_C - 2R_B}\cdot \tau_1}$$

$$\frac{1/3 - R_B/(R_B+R_C)}{2/3 - R_B/(R_B+R_C)} = \frac{R_B + R_C - 3R_B}{2R_B + 2R_C - 3R_B} = \frac{R_C - 2R_B}{2R_C - R_B}$$

$T = \Delta t_1 + \Delta t_2$

$t = t_1^+$

$V_{ci} = \frac{1}{3}V_{cc}$ $\quad \frac{2}{3}V_{cf} = V_{cf}\left(\frac{1}{3}V_{cf} - V_{cc}\right)e^{-\Delta t_2/\tau_2}$

$F = \frac{1}{\Delta t_1 + \Delta t_2} = 94'70\ Hz$

$V_{cf} = V_{cc}$

$\tau_2 = \tau_0$

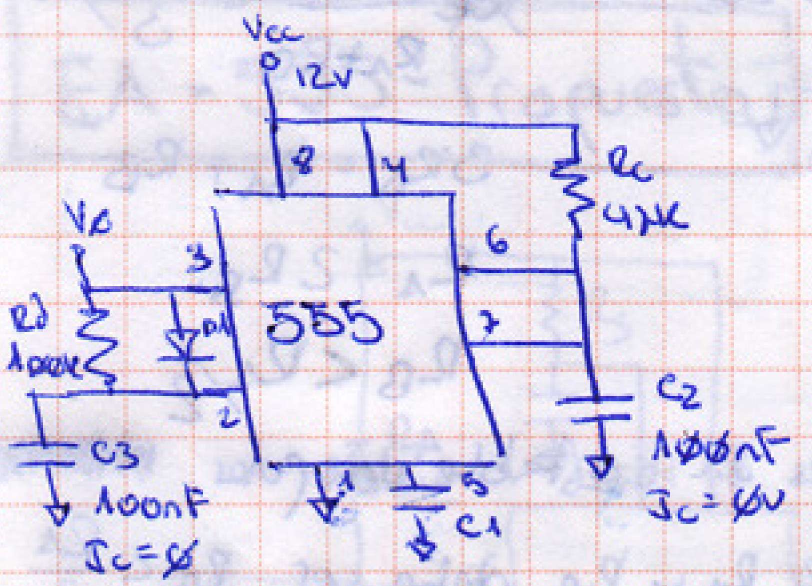
$$\frac{\frac{2}{3} - \frac{3}{3}}{\frac{1}{3} - \frac{3}{3}} = \frac{-1/3}{-2/3} \Rightarrow \boxed{\Delta t_2 = \tau_2 \ln 2}$$

$= \frac{1}{(50k // 10k)\ln\frac{50k}{10k} \cdot 470nF + 15k \cdot 470nF \ln 2}$

$470nF\left(\frac{300}{40}k + 15k\right)\cdot \ln 5\ \ln 2$

$8'3k$

EA - 555 - Propuesto ✓ #3



f sin valores numéricos

D1 es ideal, pero tiene una R muy pequeña

V_{C2} y V_{C3} → dibujar gráficos

f → valor numérico

$t = 0$

$V_{C3i} = 0$ $\quad V_{C2i} = 0$

$V_{C3f} = 12$ $\quad V_{C2f} = 12V$

$\tau_{03} = R_d \cdot 100n$ $\quad \tau_{02} = 47k \cdot 100n =$

Δt_x

$$\frac{2}{3} = 12(0 - 12)e^{-t/\tau_{02}}$$

$$\frac{\frac{24}{3} - 12}{-12} = \frac{12}{36} = \frac{1}{3} \qquad \Delta t_x = \tau_{02} \cdot \ln 3$$

$T = \Delta t_1 + \Delta t_2$

$$f = \frac{1}{\tau_{13}\ln 3 + \tau_{02}\ln\frac{3}{2}}$$

$100k \cdot 100n$ $\quad 47k \cdot 100n$

$10ms$ $\quad 4'7ms$

$13'86ms$ $\quad 0'2086ms$

Δt_1

$$\frac{12}{3} = 0 + (12 - 0)e^{-\Delta t_1/\tau_{13}} \qquad \tau_{13} = 100k \cdot 100n$$

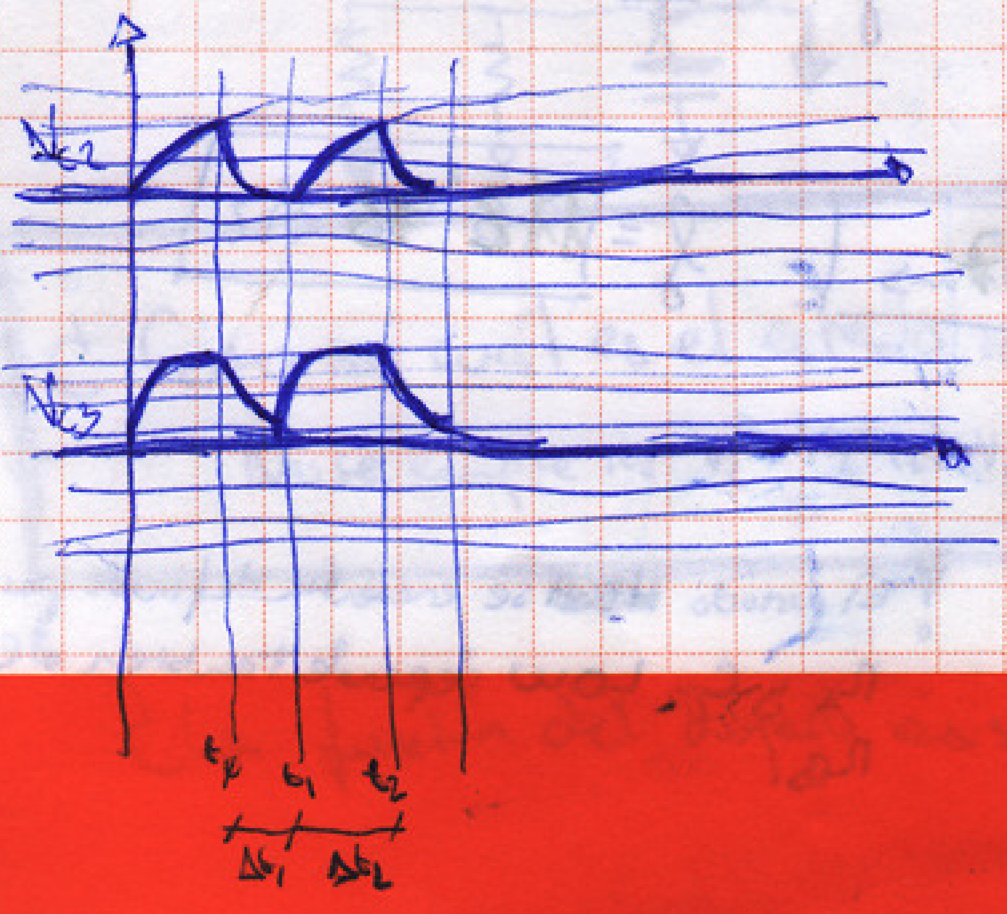
$$\frac{\frac{12}{3}}{12} = \frac{1}{3} = 3 \Rightarrow \Delta t_1 = \tau_{13}\cdot \ln 3$$

Δt_2

$$\frac{2}{3} = 12(0-12)e^{-t/\tau_{02}}$$

$$\Delta t_2 = \tau_{02} \cdot \ln\frac{3}{2}$$

$f = 69'2\ Hz$



$$f = \frac{1}{100k \cdot 100n \cdot \ln\frac{1}{4} + 47k \cdot 100n \cdot \ln\frac{12}{12}}$$

EA-555 - Problema 3

R_A y C fijos ($C1 = 1nF$ $R_L = 1k$)

a) Para algunos valores de R_B funciona. Para otros no.

¿Qué función realiza el circuito cuando funciona?

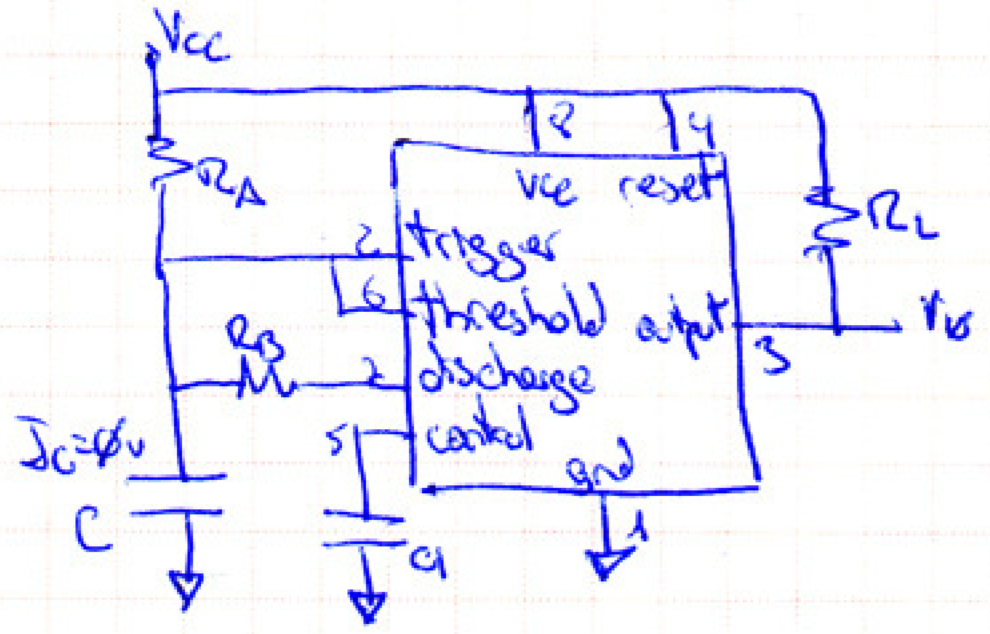
¿Qué relación ha de cumplirse entre R_A y R_B?

$T \to$ fórmula $f \to$ fórmula (cuando funciona)

b) Si $V_{cc} = 12V$, $R_A = 20K$ y $C = 470nF$

Dibujar V_c y V_0

$f \to$ valor para $R_B = 5K$ y $R_B = 20K$



$t = 0^+$

$V_{ci} = 0$

$V_{cf} = V_{cc}$

$\tau_0 = R_A \cdot C$

Δt_0

$\frac{2}{3}V_{cc} = V_{cc} + (0 - V_{cc}) e^{-\Delta t_0/\tau_0}$

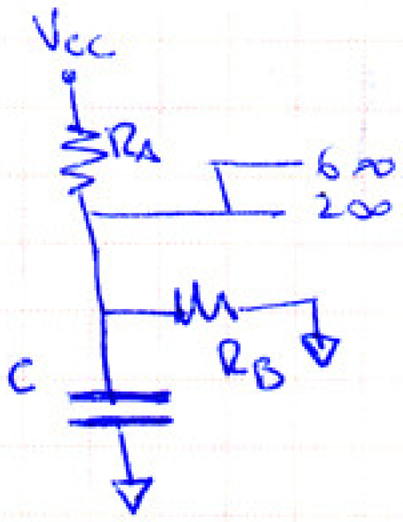
$\frac{\frac{2}{3}-1}{-1} = \frac{1/3}{3/3}$ $\boxed{\Delta t_0 = \tau_0 \ln 3}$

$t = t_0^+$

$V_{ci} = \frac{2}{3} V_{cc}$

$V_{cf} = V_{cc}\frac{R_B}{R_A + R_B}$

$\tau_1 = R_{TH} \cdot C$



$R_{TH} = R_A // R_B$

$V_{cc}\frac{R_B}{R_A+R_B} < \frac{1}{3}V_{cc}$

$3R_B = R_A + R_B$

$R_A = 2R_B$

$R_B < R_A/2$

! Cuando funciona es un aestable ~~no~~ polar

! La relación entre R_A y R_B debe ser $R_B < \frac{R_A}{2}$

$t = t_1^+$

$V_{ci} = \frac{1}{3}V_{cc}$

$V_{cf} = V_{cc}$

$\tau_2 = \tau_0 = R_A \cdot C$ $\Delta t_2 = 6'52 ms$

$\frac{2}{3}V_{cc} = V_{cc} + (\frac{1}{3}V_{cc} - V_{cc}) e^{-\Delta t_2/\tau_2}$

$\frac{\frac{2}{3}-1}{\frac{1}{3}-1} = \frac{-1/3}{-2/3} = \frac{1}{2} \Rightarrow \boxed{\Delta t_2 = \tau_2 \ln 2}$

$\frac{1}{3}V_{cc} = V_{cc}\frac{R_B}{R_A+R_B} + \left(\frac{2}{3}V_{cc} - V_{cc}\frac{R_B}{R_A+R_B}\right) e^{-\Delta t_1/\tau_1}$

$\frac{\frac{1}{3} - \frac{R_B}{R_A+R_B}}{\frac{2}{3} - \frac{R_B}{R_A+R_B}} = \frac{R_A + R_B - 3R_B}{2R_A + 2R_B - 3R_B} = \frac{R_A - 2R_B}{2R_A - R_B}$

$\boxed{\Delta t_1 = \tau_1 \ln\left(\frac{R_A - 2R_B}{2R_A - R_B}\right)}$ $\Delta t_1 = 2'36 ms$

$T = \Delta t_1 + \Delta t_2 = \tau_1 \ln\left(\frac{R_A - 2R_B}{2R_A - R_B}\right) + \tau_2 \ln 2$ $f = \frac{1}{T}$

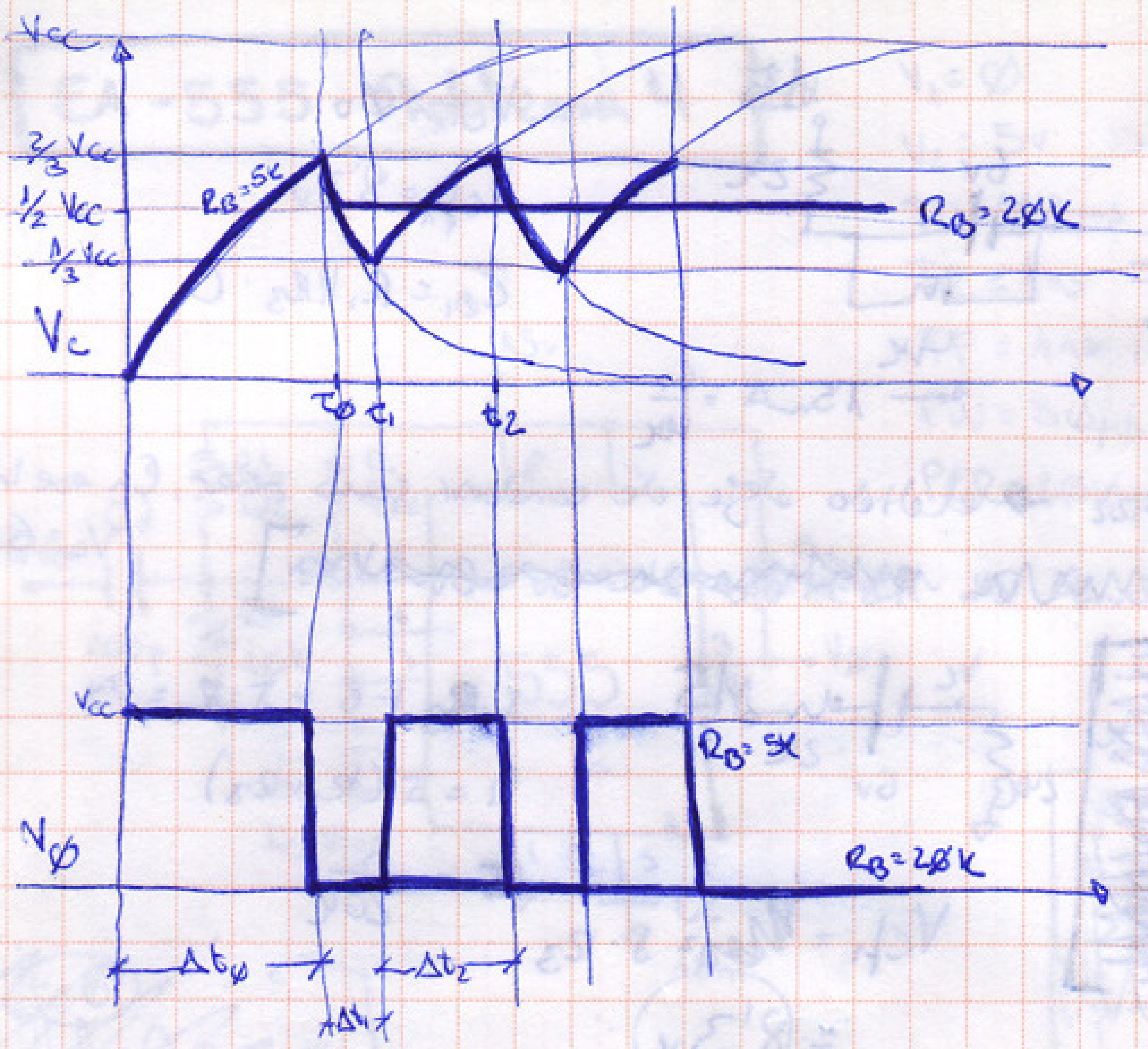
$T = 4K \cdot 470nF \cdot \ln\left(\frac{20K - 10K}{40K - 5K}\right) + \frac{20K}{470nF} \ln 2$

$= 1'88ms \cdot \ln\frac{10}{35} + \frac{\cancel{400M}}{20K} \cdot 470nF \ln 2 = \boxed{8'87 ms}$ $f = \boxed{112'73 Hz}$

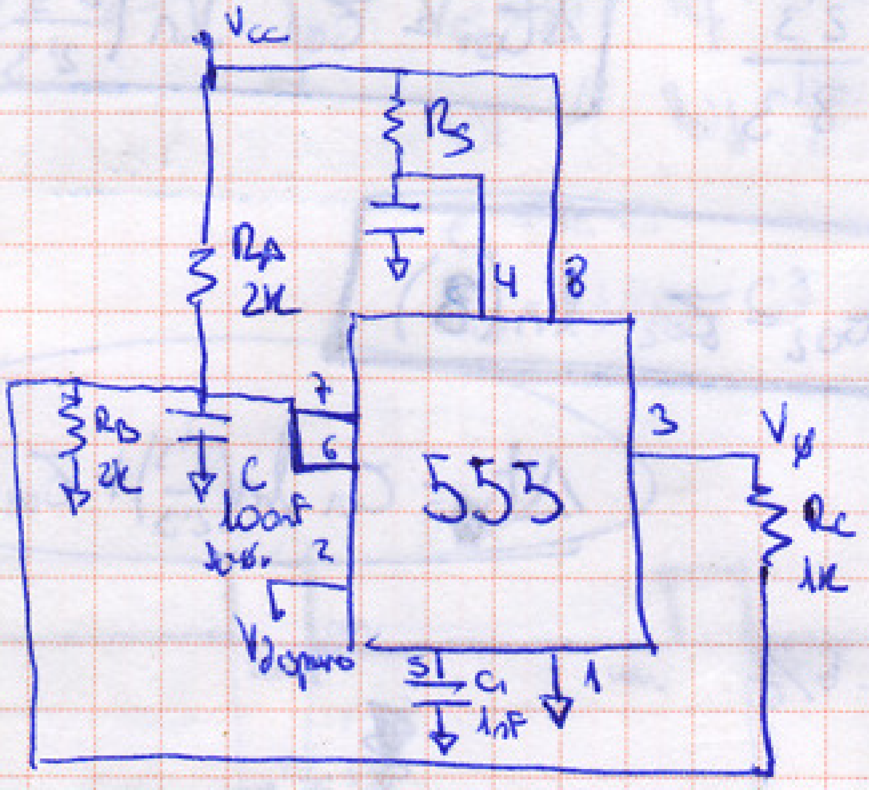
$\ln\frac{2}{7}$ 20K 9'4ms

! Si $R_B = 20K$ no podemos obtener el valor de la frecuencia, porque no llega a conmutar entre $t = t_0$ y $t = t_1$.

! El periodo ~~HIGH~~ se encuentra definido por R_A y C. LOW depende también de R_B.



EA - 555 - Propuesto



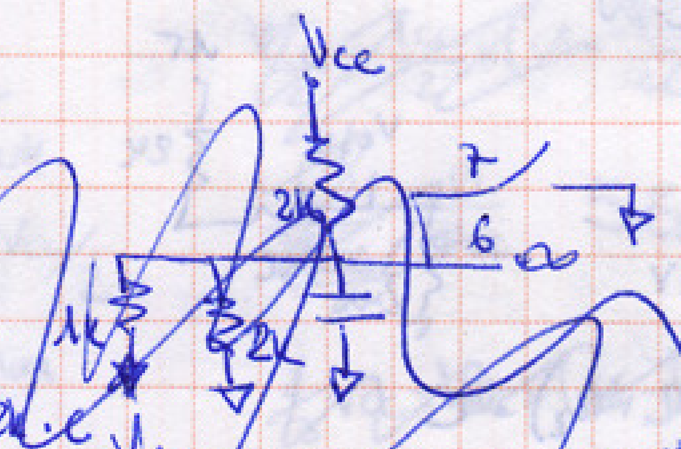
$t = 0^+$

$V_{Ci} = 0\,v$

$V_{CF} = V_{TH}$

$\tau_0 = 1k // 2k // 2k \cdot C$

$0'5k \cdot 100n = 0'05\,us$



~~El estado estable es $V_C = \frac{V_{cc}}{4}$~~

! ¿Cómo sé cuál es el estado inverso?

¿Cómo está el interruptor?

~~El estado estable es $V_C = \frac{3}{4}V_{cc}$ $V_0 = 0$ interruptor cerrado~~

$$V_{TH} = V_{cc}\,\frac{2K}{1K//2K + 2K} = \frac{3}{4}V_{cc}$$

$$\tau_0 = 1K//2K//2K \cdot C = 0'05\,us$$

$$\frac{2}{3}V_{cc} = \frac{3}{4}V_{cc} + \left(0 - \frac{3}{4}V_{cc}\right)e^{-\frac{\Delta t_{on}}{0'05\,us}}$$

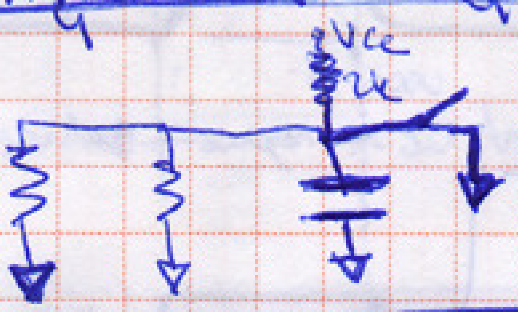
Si suponemos que int cerrado y $V_0 = 0$ al principio:

$V_C = 0\,v$ siempre

Cuando disparo $V_2 < \frac{1}{3}V_{cc}$.

$V_0 = V_{cc}$

$\boxed{\ln(9) \cdot 0'05\,us}$



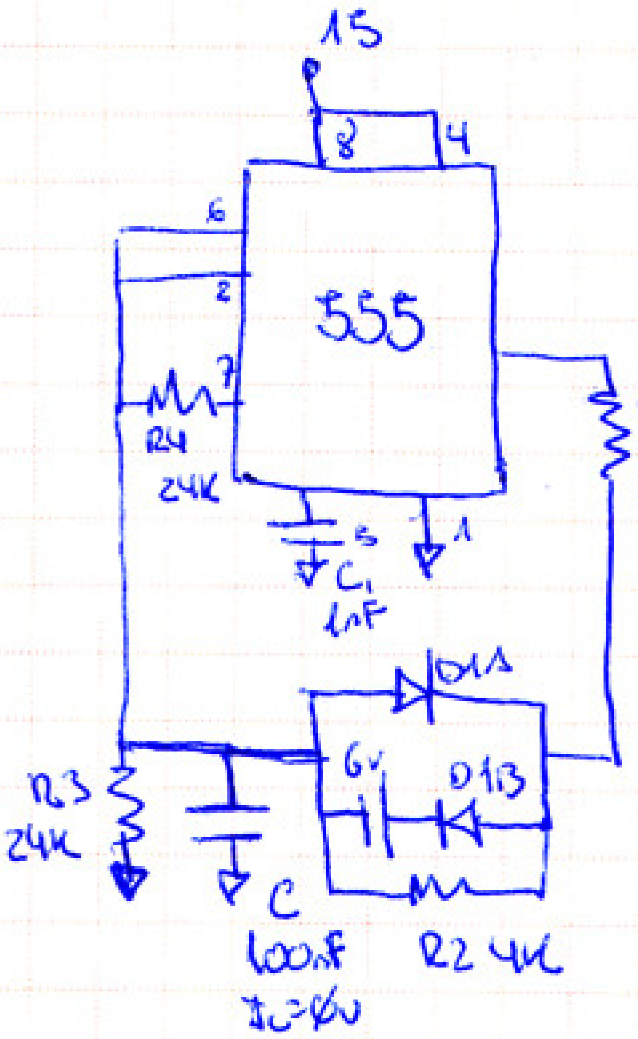
$$\frac{\frac{2}{3} - \frac{3}{4}}{-\frac{3}{4}} = \frac{\frac{8-9}{12}}{-\frac{9}{12}} = \frac{1}{9}$$

¿Cómo sé cuál es el estado inverso?

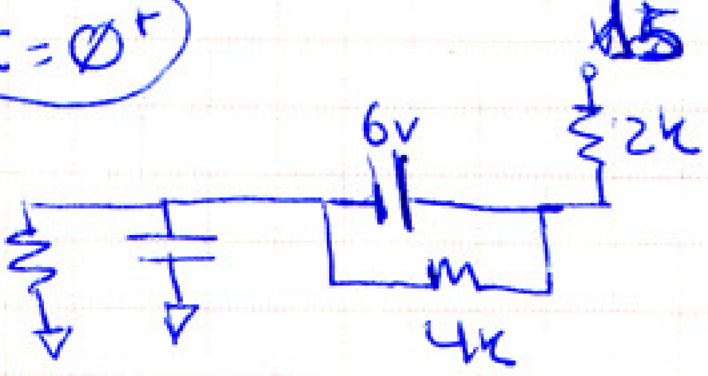
No se cumple ni $V_2 < \frac{1}{3}$ ni $V_6 > \frac{2}{3}$

¿La función del disparo es sólo abrir el interruptor?

EA - 555 - Propuesto ✓



$t = 0^+$



$\leftarrow 1'5mA = \frac{6v}{4k}$

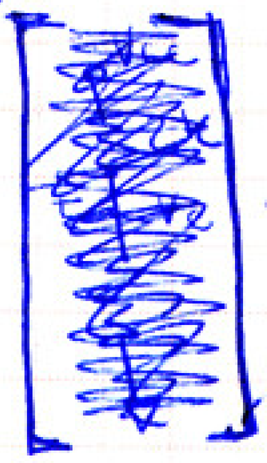
$V_{ci_1} = 0v$

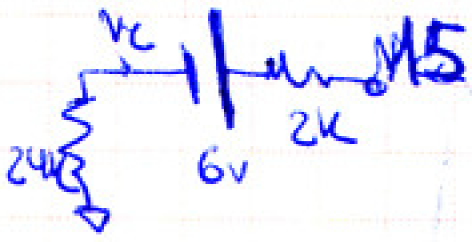
$V_{cf_1} = 8'3v$

$\tau_{01} = R_1 || R_3 \cdot C$

$I_{R1} = I_{R2}$ → el diodo deja de conducir como zener. En ese instante $V_c = 6$

~~[illegible]~~





$I \cdot R_3 + 6 + I \cdot R_1 = 15$

$9 = I(R_1 + R_3)$

$I = \frac{9}{26k}$

$V_{cf_1} = V_{R3} = I \cdot R_3$

$= 8'3v$

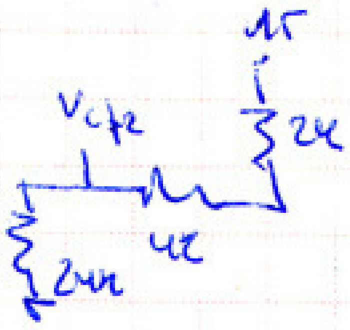
$6v = 8'3 + (0 - 8'3)\, e^{-t/\tau_{01}}$

$\frac{6 - 8'3}{-8'3} = \frac{2'3}{8'3}$

$\boxed{\Delta t_{01} = \tau_{01} \cdot \ln\left(\frac{8'3}{2'3}\right)}$

$V_{ci2} = 6v$

$V_{cf2} = 12v$



$\tau_{02} = R_3 // (R_1 + R_2) \cdot C$

$\frac{2}{3} V_{cc} = 12 + (6 - 12)\, e^{-t/\tau_{02}}$

$\frac{10 - 12}{-6} = \frac{2}{6}$

$\boxed{\Delta t_{02} = \tau_{02} \cdot \ln(3)}$

$\Delta t_0 = \tau_{01} \ln\left(\frac{8'3}{2'3}\right) + \tau_{02} \ln 3$

$t = t_0^+$

$V_{ci} = \frac{2}{3} V_{cc} = 10v$

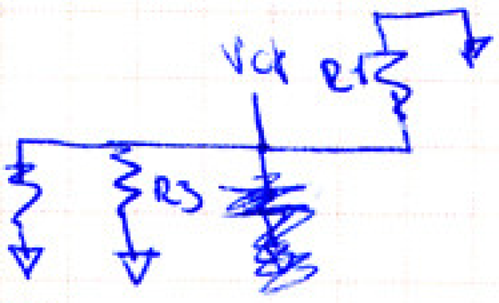
$V_{cf} = 0v$

$\tau_1 = R_1 // R_3 // R_4 \cdot C$

$\frac{1}{3} V_{cc} = 0 + \left(\frac{2}{3} V_{cc} - 0\right) \cdot e^{-t/\tau_1}$

$\frac{5}{10}$

$\boxed{\Delta t_1 = \tau_1 \ln 2}$



$t = t_1^+$

$V_{ci1} = 5v$

$V_{cf_1} = 8'3v$

$\tau_{21} = \tau_{01}$

$6v = 8'3 + (5v - 8'3)\, e^{-t/\tau_{01}}$

$\frac{6 - 8'3}{-3'3} = \frac{2'3}{3'3}$

$\boxed{\Delta t_{21} = \tau_{01} \cdot \ln \frac{3'3}{2'3}}$

$V_{ci2} = 6v$

$V_{cf2} = 12v$

$\tau_{22} = \tau_{02}$

$10 = 12 + (6 - 12) \cdot e^{-t/\tau_{02}}$

$\boxed{\Delta t_{22} = \Delta t_{02} = \tau_{02} \cdot \ln 3}$

$\Delta t_2 = \tau_{01} \cdot \ln\left(\frac{3'3}{2'3}\right) + \tau_{02} \cdot \ln 3$

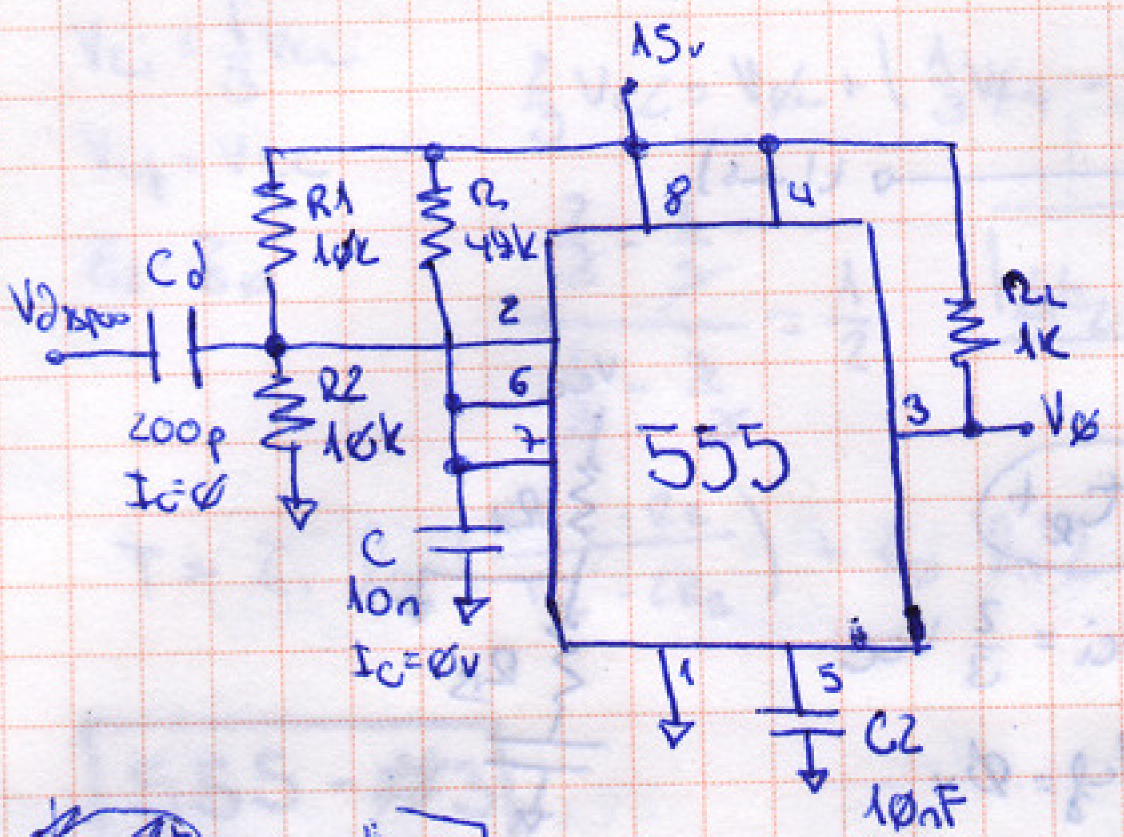
EA - 555 - Problema 4

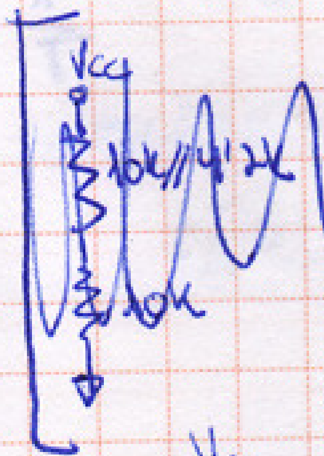
$V_1 = \emptyset$
$V_2 = 5v$
$TD = \emptyset'2\,ms$
$TR = 1ns$
$TF = 1ns$
$PW = 5\emptyset\mu s$
$PER = 2\emptyset\emptyset\,\mu s$

Analizar todo el circuito desde $t=\emptyset$ hasta $t=\emptyset'6ms$

¿Cuál es el principal defecto de este monoestable y su circuito de disparo, con las condiciones iniciales mostradas en el esquema?

~~Funciona como astable porque R, R1 y R2 no limitan bien la tensión por debajo de $\frac{2}{3}V_{cc}$~~





$V_{th} = V_{cc}\,\frac{10k}{10k//42k + 10k}$

$R_{th} = 10k//10k//4'2k = 2'42k$

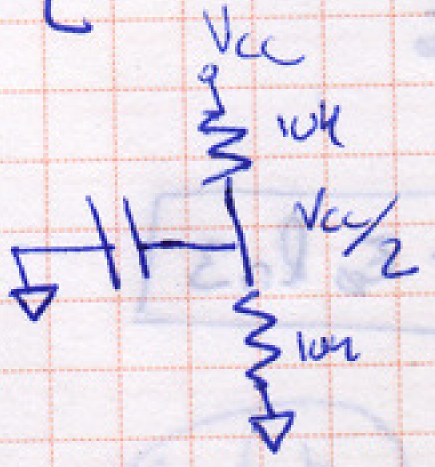
$t = \emptyset^+$

$V_{c} = \emptyset \qquad V_{cf} = V_{cc}$

$V_{cd} = \emptyset \qquad V_{cdf} = \frac{V_{cc}}{2}$

$\tau_c = R\cdot C$

$\tau_{cd} = R1//R2 \cdot Cd$



~~$\frac{V_{cc}}{2} = \frac{V_{cc}}{2} + (\emptyset - \frac{V_{cc}}{2})e^{-t/\tau_{cd}}$~~

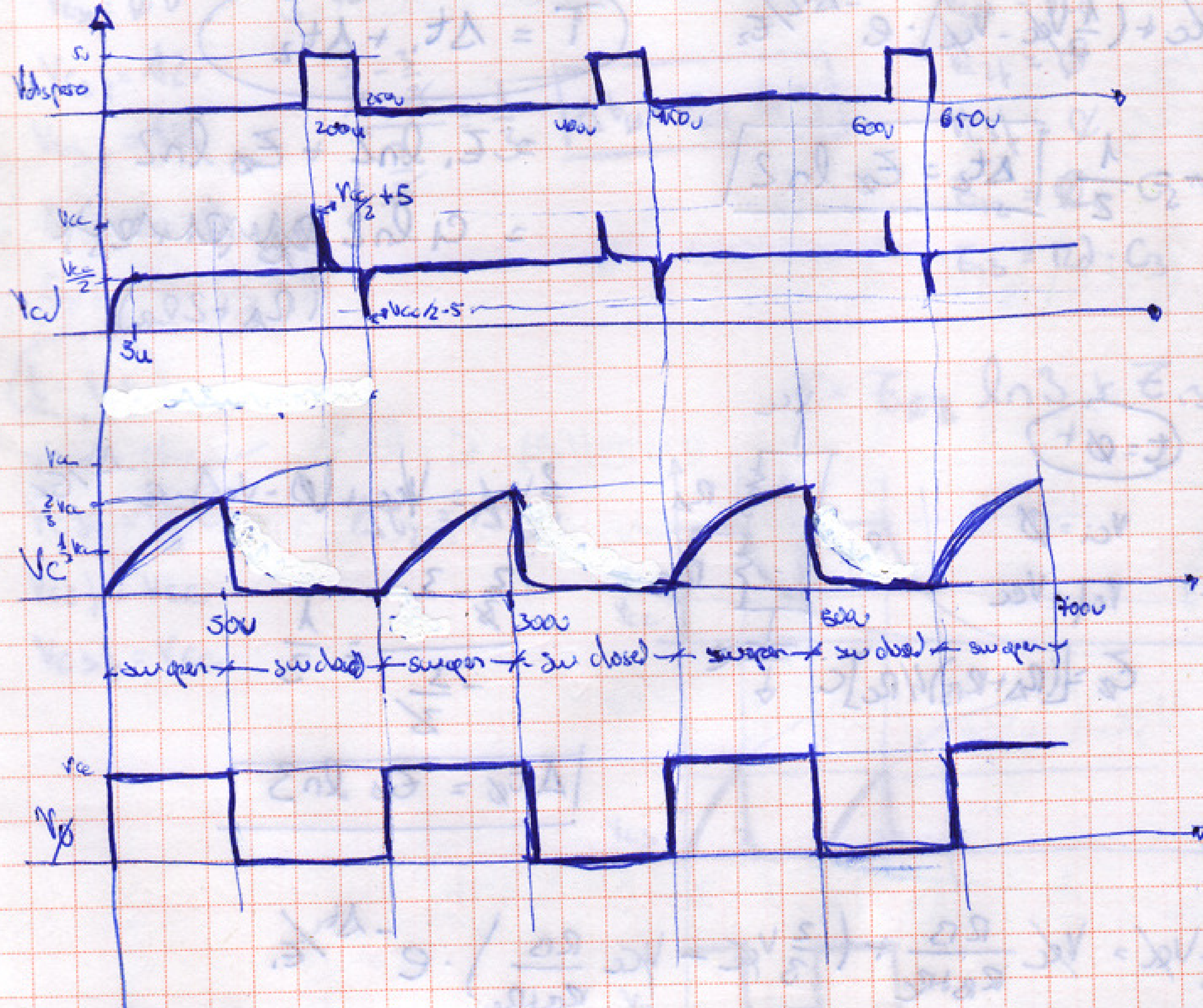
$5\tau_{cd} = 5\,R1//R2\,C$

$$\frac{\frac{2}{3} - \frac{3}{3}}{-\frac{3}{3}} = \frac{1}{3} \qquad t = \tau_c \ln 3$$

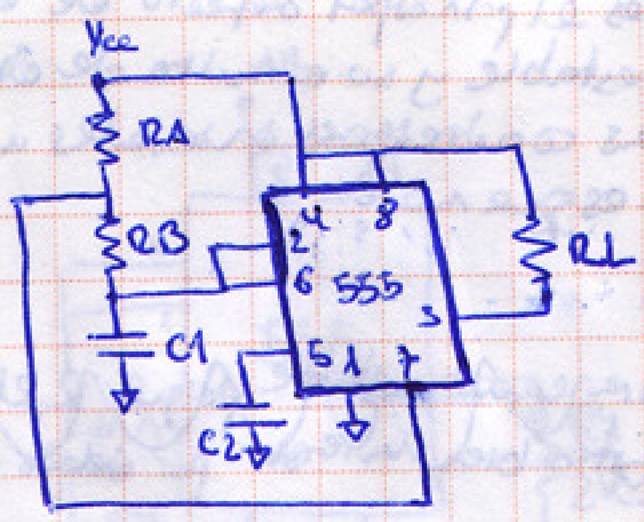
$5\tau_c = 5\cdot R\cdot C$

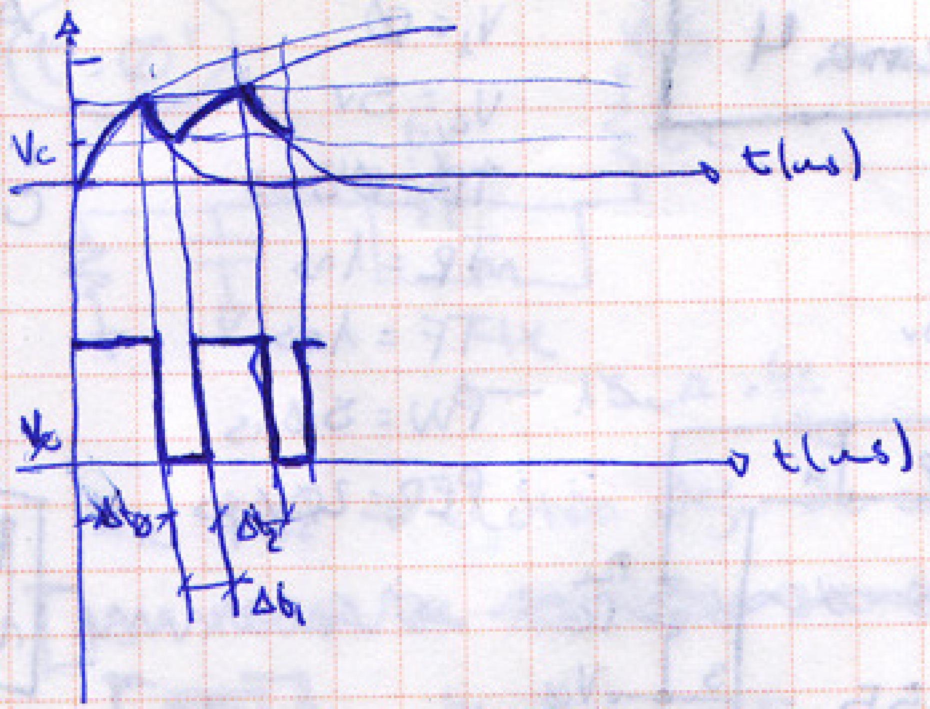
$1'9 = 15 + (\emptyset - 15)\,e^{-t/RC}$

$\frac{1'9 - 15}{-15} \quad \ln\frac{15}{13'1}\cdot 42k\cdot 10n$



EA - 555 - #1



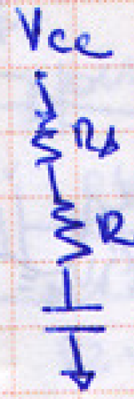


$t = 0^+$

$V_{ci} = 0\,V$

$V_{cf} = V_{cc}$

$\tau_0 = (R_A + R_B)\,C1$



$$\frac{2}{3}\cancel{V_{cc}} = \cancel{V_{cc}} + (0 - \cancel{V_{cc}})\, e^{-\Delta t_0/\tau_0}$$

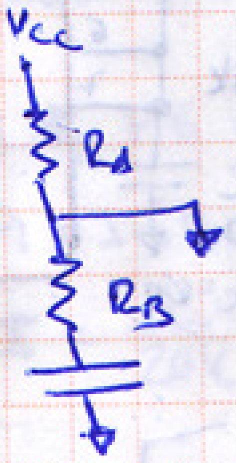
$$\frac{\frac{2}{3} - 1}{-1} = \frac{1/3}{3/3} = \frac{1}{3} \qquad \boxed{\Delta t_0 = \tau_0 \ln 3}$$

$t = t_0^+$

$V_{ci} = \frac{2}{3} V_{cc}$

$V_{cf} = 0\,V$

$\tau_1 = R_B \cdot C1$



$$\frac{1}{3}\cancel{V_{cc}} = \left(\frac{2}{3}\cancel{V_{cc}} - 0\right) \cdot e^{-\Delta t_1/\tau_1}$$

$$\frac{\frac{1}{3}}{\frac{2}{3}} = \frac{1}{2} \qquad \boxed{\Delta t_1 = \tau_1 \ln 2}$$

$t = t_1^+$

$V_{ci} = \frac{1}{3} V_{cc}$

$V_{cf} = V_{cc}$

$\tau_2 = \tau_0$

$$\frac{2}{3}\cancel{V_{cc}} = \cancel{V_{cc}} + \left(\frac{1}{3}\cancel{V_{cc}} - \cancel{V_{cc}}\right) \cdot e^{-\Delta t_2/\tau_2}$$

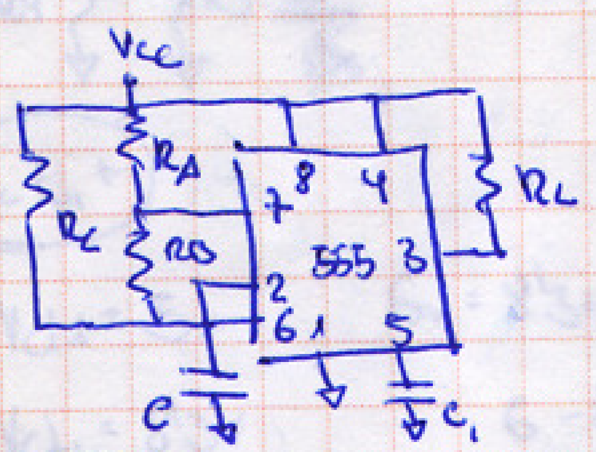
$$\frac{\frac{2}{\cancel{3}} - \frac{3}{\cancel{3}}}{\frac{1}{\cancel{3}} - \frac{3}{\cancel{3}}} = \frac{1}{2} \qquad \boxed{\Delta t_2 = \tau_0 \ln 2}$$

$$T = \Delta t_1 + \Delta t_2$$

$$= \tau_1 \ln 2 + \tau_0 \ln 2$$

$$= C_1 \ln 2\, (R_A + 2R_B)$$

555 - #2

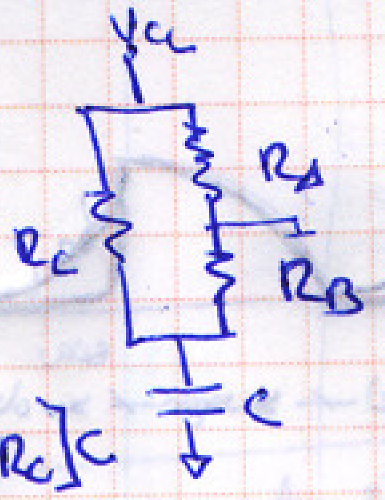


$t = 0^+$

$V_{ci} = 0$

$V_{cf} = V_{cc}$

$\tau_0 = [(R_A + R_B) // R_C]\, C$



$$\frac{2}{3}\cancel{V_{cc}} = \cancel{V_{cc}} + (0 - \cancel{V_{cc}}) \cdot e^{-\Delta t_0/\tau_0}$$

$$\frac{\frac{2}{\cancel{3}} - \frac{3}{\cancel{3}}}{-\frac{3}{\cancel{3}}} = \frac{1}{3}$$

$$\boxed{\Delta t_0 = \tau_0 \ln 3}$$

$t = t_0^+$

$V_{ci} = \frac{2}{3} V_{cc}$

$V_{cf} = V_{cc} \cdot \frac{R_B}{R_B + R_C}$

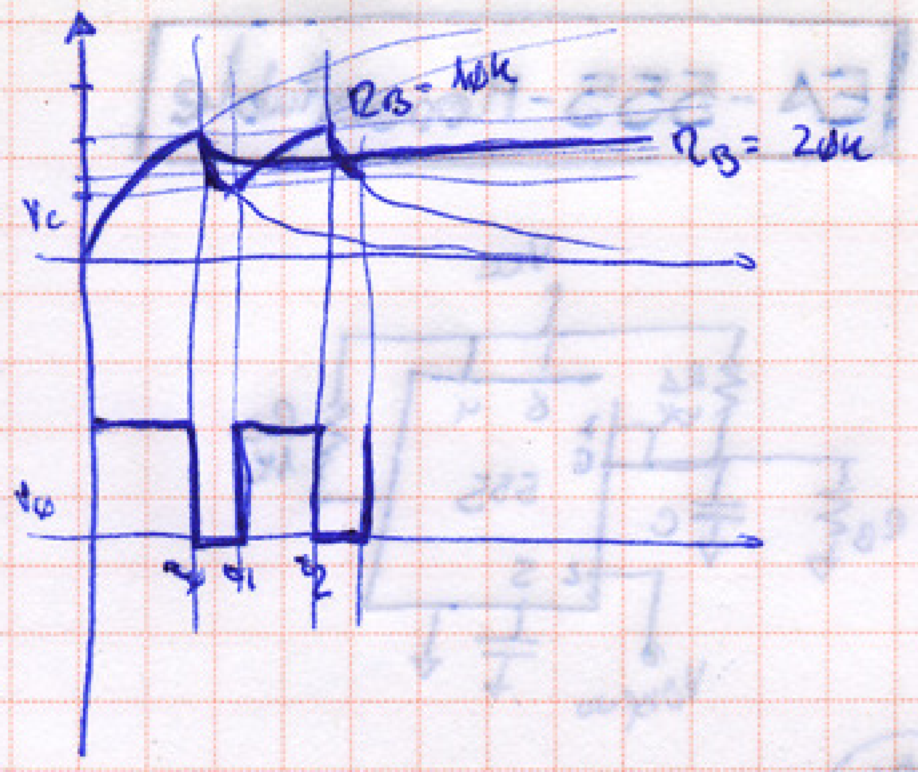
$\tau_1 = (R_B // R_C)\, C$

$$\frac{1}{3}\cancel{V_{cc}} = \cancel{V_{cc}} \frac{R_B}{R_B + R_C} + \left(\frac{2}{3}\cancel{V_{cc}} - \cancel{V_{cc}} \frac{R_B}{R_B + R_C}\right) \cdot e^{-\Delta t_1/\tau_1}$$

$$\frac{\frac{1}{3} - \frac{R_B}{R_B + R_C}}{\frac{2}{3} - \frac{R_B}{R_B + R_C}} = \frac{R_B + R_C - 3R_B}{2R_B + 2R_C - 3R_B} \qquad \frac{R_C - 2R_B}{2R_C - R_B}$$

$$\cancel{V_{cc}} \frac{R_B}{R_B + R_C} < \frac{1}{3} \cancel{V_{cc}} \qquad 3R_B < R_B + R_C \qquad 2R_B < R_C$$

$$\boxed{\Delta t_1 = \tau_1 \ln\left(\frac{2R_C - R_B}{R_C - 2R_B}\right)}$$



$t = t_1^+$

$V_{Ci} = \frac{1}{3} V_{CC}$

$V_{Cf} = V_{CC}$

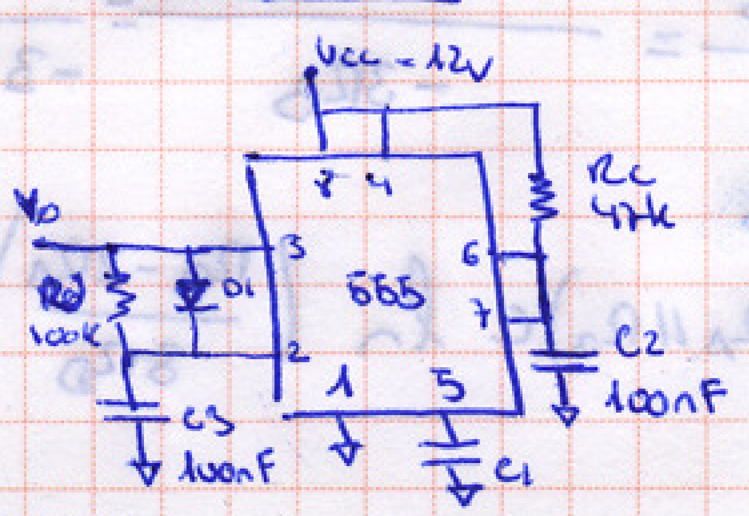
$\tau_2 = \tau_0$

$$\frac{2}{3} V_{CC} = V_{CC} + \left(\frac{1}{3} V_{CC} - V_{CC}\right) \cdot e^{-\Delta t_2/\tau_2}$$

$$\frac{\frac{2}{3} - \frac{3}{3}}{\frac{1}{3} - \frac{3}{3}} = \frac{1}{2} \qquad \boxed{\Delta t_2 = \tau_0 \ln 2}$$

$$T = \tau_1 \ln\left(\frac{2R_C - R_B}{R_C - 2R_B}\right) + \tau_0 \ln 2 \qquad f = \frac{1}{T}$$

555 - #3



$t = 0^+$

$V_{C2i} = 0\,V$

$V_{C3i} = 0\,V$

$V_{C2f} = 12\,V$

$V_{C3f} = 12\,V$

$\tau_{02} = R_C \cdot C_2$

$\tau_{03} = R_D \cdot C_3 \simeq 0$

$$\frac{2}{3} \cdot 12 = 12 + (0 - 12) \cdot e^{-\Delta t_0/\tau_{02}}$$

$$\frac{\frac{2}{3} - \frac{3}{3}}{-\frac{3}{3}} = \frac{1}{3} \qquad \boxed{\Delta t_0 = \tau_{02} \ln 3}$$

$t = t_0^+$

$V_{C2i} = \frac{2}{3} V_{CC}$

$V_{C3i} = V_{CC}$

$V_{C2f} = 0$

$V_{C3f} = 0$

$\tau_{12} = R_? \cdot C_2 \simeq 0$

$\tau_{13} = R_D \cdot C_3$

$$\frac{1}{3} V_{CC} = 0 + (V_{CC} - 0) \cdot e^{-\Delta t_1/\tau_{13}}$$

$$\frac{1/3}{3/3} \qquad \boxed{\Delta t_1 = \tau_{13} \cdot \ln 3}$$

$$T = \tau_{02} \ln 3 + \tau_{13} \ln 3 = \ln 3 \,(R_C \cdot C_2 + R_D \cdot C_3)$$

$t = t_1^+$

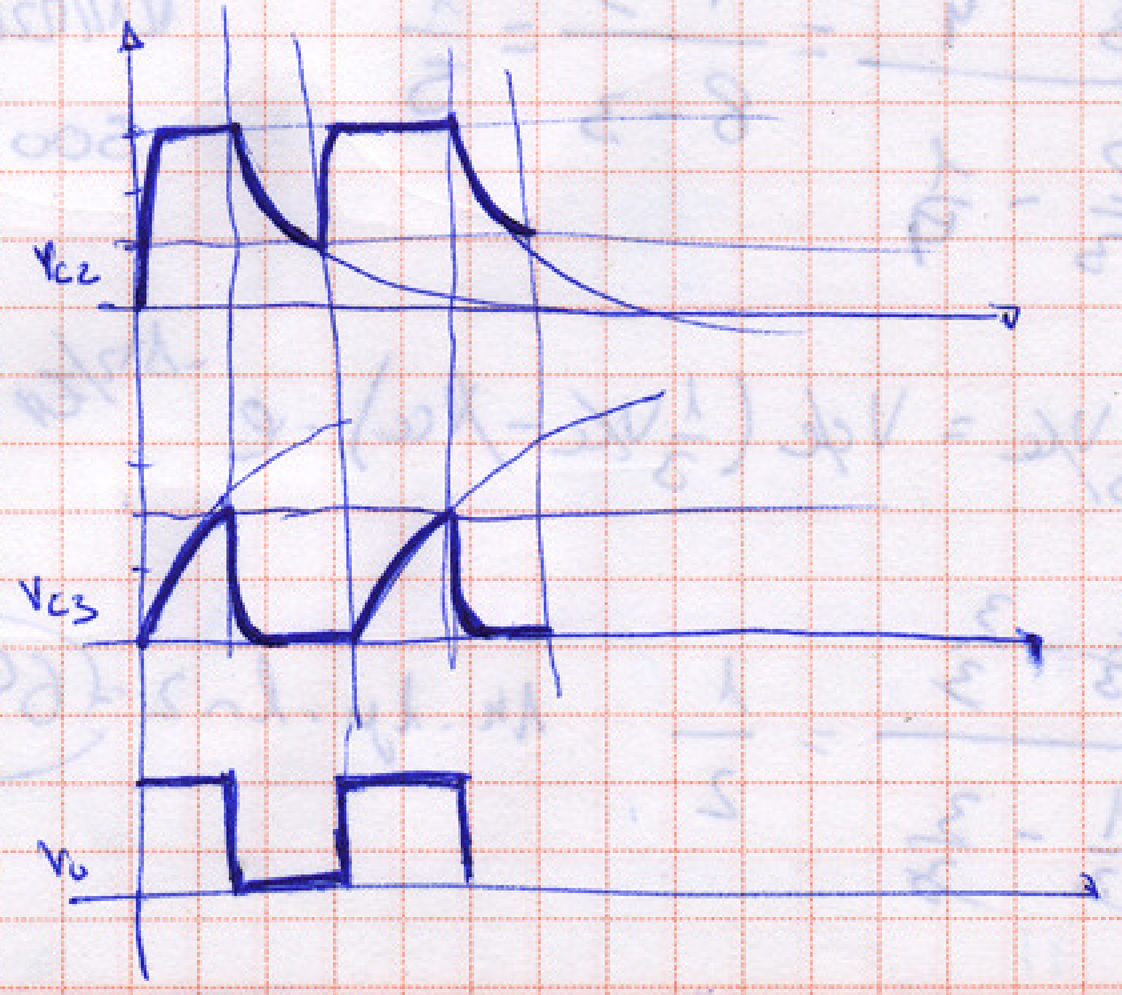
$V_{C2i} = 0\,V$

$V_{C3i} = V_{CC}$

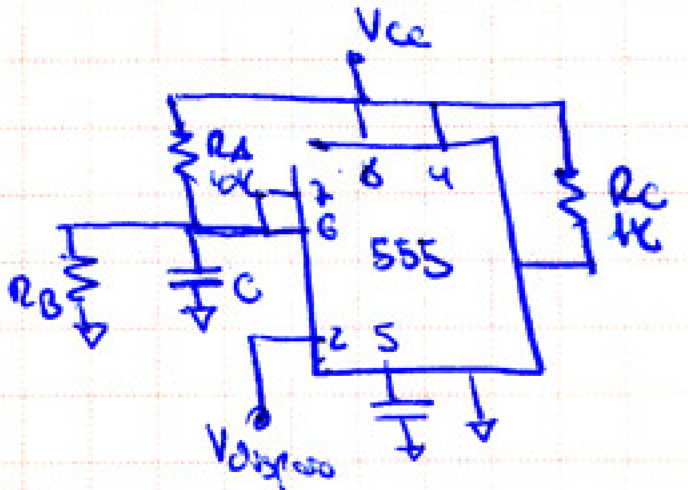
$V_{C2f} = V_{CC}$

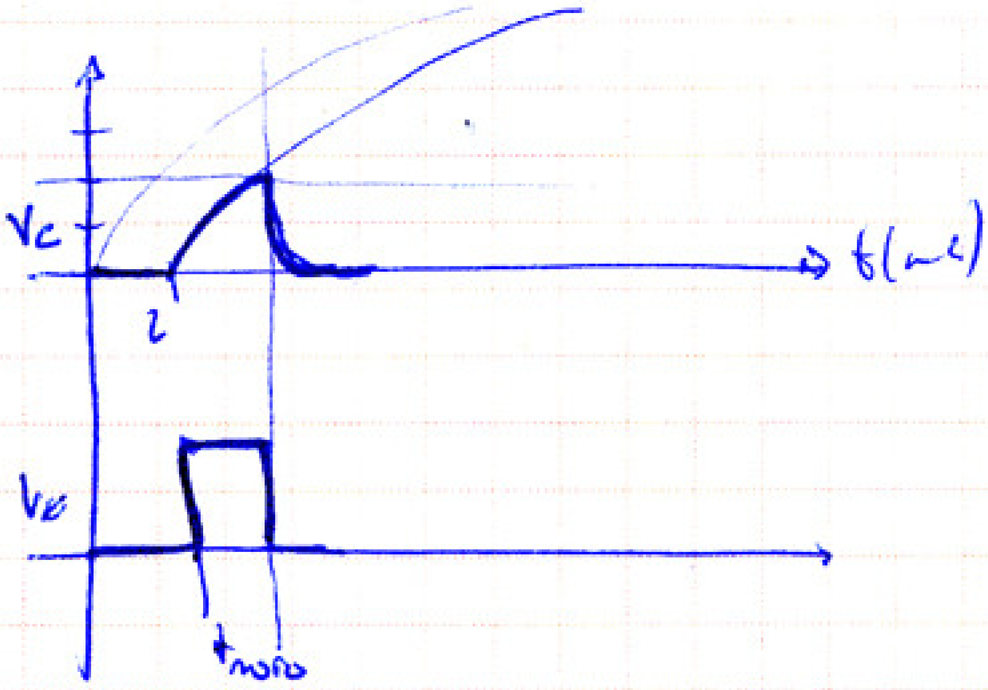
$V_{C3f} = V_{CC}$

$\Delta t_2 = \Delta t_0$



EA - 555 - Monoestable





$t = t_{mono}$

$V_{ci} = 0V$

$V_{cf} = V_{cc}\frac{R_B}{R_A+R_B}$

$\tau_0 = (R_A // R_B)\,C$

$V_{cc}\frac{R_B}{R_A+R_B} > \frac{2}{3}V_{cc}$

$3R_B > 2R_A + 2R_B$

$R_B > 2R_A$

$\frac{2}{3}V_{cc} = V_{cc}\frac{R_B}{R_A+R_B} + \left(0 - V_{cc}\frac{R_B}{R_A+R_B}\right)\cdot e^{-\Delta t_{mono}/\tau_0}$

$$\frac{\frac{2}{3} - \frac{R_B}{R_A+R_B}}{-\frac{R_B}{R_A+R_B}} = \frac{2R_A+2R_B-3R_B}{-3R_B} = \frac{2R_A-R_B}{-3R_B}$$

$\Delta t_{mono} = (R_A // R_B)\,C\,\ln\left(\frac{R_B-2R_A}{3R_B}\right)$

$$\frac{\frac{2(R_A+R_B)}{3(R_A+R_B)} - \frac{3R_B}{3(R_A+R_B)}}{-\frac{3R_B}{3(R_A+R_B)}}$$

$\frac{R1//R4}{R2+R1//R4} = \frac{2/3}{2+2/3} = \frac{2/3}{8/3} = \frac{1}{4}$ 3v

$\frac{1}{3}V_{cc} = \frac{1}{4}V_{cc}\left(\frac{2}{3}V_{cc} - \frac{1}{4}V_{cc}\right)e^{-\Delta t_1/\tau_1}$

$$\frac{\frac{1}{3}-\frac{1}{4}}{\frac{2}{3}-\frac{1}{4}} = \frac{4-3}{8-3} = \frac{1}{5}$$

$R1//R2//R4 \cdot C \cdot \ln 5$

$500 \cdot 1\mu \cdot \ln 5 = 804'72\,\mu s$

$\frac{2}{3}V_{cc} = V_{cc}\left(\frac{1}{3}V_{cc} - V_{cc}\right)\cdot e^{-\Delta t_2/\tau_0}$

$$\frac{\frac{2}{3}-\frac{3}{3}}{\frac{1}{3}-\frac{3}{3}} = \frac{1}{2}$$

$1k \cdot 1\mu \cdot \ln 2 = 693'14\,t$ $e^{-T/Z}$

$4 = 3 + (8-3)\,e^{-T/Z}$

$\ln\frac{1}{5}\,e^{-T/Z}$

$\ln 0'4$

$\ln 0'2 = -T/Z$